THE
ENGINEERING REVIEW.

Edited by
C. EDGAR ALLEN.

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THE MONTH.

THE TRAFFIC COMMISSION REPORT.—The report of the Royal Commission on London traffic has been published. Vol. I. contains the report proper, and seven other volumes will appear shortly containing appendices, maps, and diagrams, and the report of the Board of Engineers appointed by the committee to inquire into the engineering aspects of the general problem. As our readers will doubtless remember, this board consisted of Sir J. Wolfe Barry, Sir Benjamin Baker, and Mr. W. Barclay Parsons of New York. The report as a whole will certainly be the most comprehensive treatise ever compiled on the subject of urban locomotion, dealing with traffic facilities in the chief cities of Europe and America as well as with those existing in and proposed for London. The Commissioners have considered the problem on broad lines, leaving various matters of detail to be dealt with by the suggested Traffic Board. We are glad to see that friendly relations are recommended among the local authorities of London and Greater London, and all companies engaged in working railways, tramways, and other means of facilitating transport in and around the metropolis. The amalgamation of the various underground and tubular railways is pointed out as a possible way of securing to the public the advantages arising from unity of interest and management. The extension of electric tramways is warmly advocated, and especially the linking up of the present disconnected units of the general system. Further, the Commission propose various street and road improvements, including the construction of two main avenues, from north to south and from east to west, each with four surface tramway lines and four shallow subway electric railways. This is another very important recommendation, but the enormous cost involved will no doubt prevent its realisation for some time to come. It is comparatively easy to evolve great schemes, but the difficulty will always be money. The practical promotion of traffic projects will remain with local authorities and public companies, none of whom are likely to deal with more than comparatively small sections of the metropolis. Hence, piecemeal methods are almost inevitable, and the greatest benefit to be anticipated from the report will probably be found in the creation of the central Traffic Board to regulate and co-ordinate the isolated schemes brought forward by independent authorities and companies.

THE ESSEN TURBINE PLANT.—Two steam turbines of 10,000 h.-p. now in course of erection in the Rhine-Westphalian Electricity Works at Essen represent the largest prime movers of this class hitherto built. These machines were made by Messrs. Brown, Boveri & Co., of Baden,

and each of them is direct-coupled to a 5,000 kilowatt alternator and a 1,500 kilowatt direct-current generator. The total weight of the set is 190 tons, which is considerably less than that of the moving parts alone of a smaller reciprocating engine generating set. According to the terms of the contract the makers are required to show a steam consumption not exceeding 8·8 lb. per indicated horse-power hour. Assuming this guarantee to be successfully complied with the new turbines will show a higher efficiency than any other prime mover in the world. We believe the steam consumption in the power station for the New York subway is 12·25 lb. per indicated horse power, a figure which is about 40 per cent. more than that promised for the Essen turbines.

THE EFFECT OF HEAT UPON CONCRETE.—In a paper read before the American Society for testing materials, Professor Ira H. Woolson gives an interesting account of an investigation, undertaken at the request of the joint committee on concrete and reinforced concrete, for the purpose of ascertaining the effect of heat upon the crushing strength and elastic properties of concrete. The methods of construction and the character of the tests were based on the American Municipal Specification and the rules of the British Fire Prevention Committee, the concretes tested being in the proportions of 1:2:4 and 1:2:5 and having aggregate of trap rock and limestone. Numerous tables and curves are given in the paper. Taking mean values it appears that the crushing strength of trap and limestone cubes and prisms ranged from 1,600 lb. per sq. in. at normal temperature down to 300 lb. per sq. in. at 2,000° Fahr., the highest results being 1,900 lb. per sq. in. at normal temperature to 840 lb. per sq. in. at 2,000° for trap concrete, and the lowest results 1,350 lb. per sq. in. at normal temperature to 260 lb. per sq. in. at 1,500° for limestone concrete. The mean coefficients of elasticity ranged 3,200,000 lb. per sq. in. at normal temperature, down to 100,000 lb. at 1,500° Fahr. for both limestone and trap concrete. Other experiments proved that the heat conductivity of the concrete was very low, a point as satisfactory in its way as the serious diminution of strength is unsatisfactory from the constructive standpoint. This investigation indicates the necessity for limiting the calculated stresses in the case of concrete or reinforced concrete structures which may be exposed to considerable temperatures.

WATER-TUBE LOCOMOTIVES.—With the object of obviating troubles experienced with locomotive boilers, M. Robert, the locomotive engineer of the Algerian lines of the Paris-Lyons and Mediterranean Railway, has designed an engine with a water-tube boiler having two horizontal drums connected by three water legs and some 420 tubes. The fire-box is formed by an extension of the lower drum and a number of vertical tubes. At first the tubes were made of copper, but experience showed that minute cracks were developed after some 25,000 miles had been run. Hence, steel tubes were substituted, and with these runs aggregating nearly 40,000 miles were made without any ill effects. Owing to the facility with which the water-tube boiler can be forced the capacity of the engine is far greater than that of an ordinary locomotive with engines of similar size, especially when ascending heavy gradients. The sensitive character of the water-tube boiler is also found serviceable when descending hills, as the steam pressure can be reduced very readily. This type of locomotive is certainly a novelty which may be useful in exceptional circumstances.

SINGLE-PHASE MOTORS FOR ELECTRIC TRACTION.—Following the unfortunate experience of the Metropolitan District Railway with the three-rail system, we have an illustration of the danger attaching to this method of traction in the narrow escape of two lads who were caught by a live conductor on the Lancashire and Yorkshire Railway near Liverpool, and were only rescued just in time to avoid being killed by a passing train. In a previous issue of "THE ENGINEERING REVIEW" * we gave particulars of the single-phase overhead traction on the Ballston branch of the Schnectady Railway—a system presenting manifest advantages in the way of economy and none of the disadvantages inseparable from the use of a third rail. Further experiments in the same direction are now being made on a tramway line in Paris. One car is at present used for the purpose, the ordinary direct-current motors having been removed and replaced by single-phase motors. So far, the results of the tests have been perfectly satisfactory, and it is probable that the new motors will be adopted on an extensive scale. It is very strange that the subject is so little considered in this country, especially as the use of

* Vol. xi., p. 233.

alternating current with single-phase motors offers a saving in capital expenditure and working expenses of at least one-third, as compared with the customary direct-current-system.

THE NEW YORK DOCK FIRE.—Owing to a fire which broke out last month at the Ferry House Station of the Delaware and Lackawanna Railroad at Hoboken, opposite New York, damage to the extent of more than £300,000 was caused to the Railroad Company alone. The dock sheds of the North German Lloyd and Hamburg-American lines were threatened, but owing to the fact that fire-resisting construction was adopted after the appalling disaster of 1900, these structures suffered no material damage. We have no doubt the buildings destroyed will be re-erected in more suitable material, but it seems to be a great pity that so many of these combustible buildings should be allowed to remain until a disastrous conflagration comes as a reminder that inflammable structures are inadvisable.

STANDARDISATION OF TRADE CATALOGUES.—A movement recently commenced in the United States deserves imitation in this country. Its object is to induce manufacturers and others to adopt certain defined sizes for catalogues and pamphlets, a most desirable consummation to consulting engineers and others who have occasion to keep such publications for office reference. Many firms already issue their lists in books of convenient size, but there are numerous manufacturers who persist in adopting the most ungainly dimensions. One result of this ill-advised practice is that expensive catalogues cannot be preserved in book cases, and after lying about on shelves or tables for some time, are very often destroyed so as to get them out of the way. We do not know of any organisation capable of taking this matter up. Still, manufacturing firms could easily effect the necessary reform, if they were once convinced of the self-inflicted injury that results from the adoption of preposterous dimensions for their publications.

MOTOR-CAR ENGINES.—An eminent automobile engineer has recently expressed the opinion that a racing car cannot be built to exceed the speed of one hundred and thirty miles an hour unless some reduction be made in the present weight. Apparently fired by the determination to approach this limit as closely as possible, M. Serpollet has decided to construct a steam car to run at an average speed of one hundred and twenty-five miles an hour. There may be a good deal of excitement to be got out of such rapid travelling, but it would be more beneficial to automobilism and the general public if engineers would turn their attention to the design of cars with engines calculated to do their work more quietly and to consume their fuel more completely than the motors now in use. Even at its best the petrol car must be a machine for the production of carbonic acid gas on a large scale, and there is no reason why the manufacture of this deleterious substance should be accompanied by unnecessary noise and smell. We should be glad to see automobile engineers who now waste their energies on the building of useless racing cars, devote themselves to improvements better calculated to popularise motor vehicles.

COLLAPSE OF THE MEYERS BUILDING.—Steel-cage and skeleton buildings are generally considered to be so adequately supported by the steel framework as to make collapse impossible. The framework is supposed to be so well designed and its members so interconnected one with another as to put complete failure out of question so long as the steel remains uninjured by corrosion. These views are correct, but there is a class of skeleton building which is far less secure, having cast-iron columns for support of the wall and floor loads. The Hotel Darlington, which collapsed during construction last year, was of this type, and so we assume, was the Meyers store building at Albany, which suddenly sank into a confused heap of metal and brick only two or three weeks ago. The Hotel Darlington failure was due to the fact that the cast-iron columns had insufficient lateral support, and the Meyers Building disaster to the temporary removal of some columns during the rebuilding of the front. Cast iron is an excellent material for resisting direct compression, but when applied in the form of columns connected so as to be continuous from foundation to roof, it is extremely liable to failure by tension if flexure should arise from any miscalculation, defective workmanship, or any unforeseen alterations of the assumed conditions of loading. We do not know positively that cast iron was so employed in the Meyers building, but the utter ruin which suddenly overtook this structure points to the probability that such was the case.

THE OVER-BRIDGE TRAMWAYS. — Considerable indignation has been aroused by the refusal of the House of Lords to pass the Bill containing proposals for connecting the Westminster and Blackfriars tramway lines by means of a route along the Victoria Embankment. We cannot help regarding the decision as a temporary lapse from the good judgment usually shown by the Upper House, the members of which evidently have very little knowledge of the pressing necessity for this particular line. The tramway termini in the middle of busy streets such as Blackfriars Road and Westminster Bridge Road constitute a great obstacle to ordinary traffic, and cause much inconvenience and discomfort to intending passengers, Each terminus is on the wrong side of the river, and thousands upon thousands of passengers have to cross the bridges daily on foot or by omnibus. Local traffic on the Embankment itself is not so much a *desideratum* as through communication between the Westminster and Blackfriars lines, that would have the effect of abolishing the existing obstructions and the nightly struggle for seats now occurring at each of the terminals. The House of Lords have made a sad blunder, which we confidently expect will be rectified next session, when the Bill is again brought forward by the London County Council.

THE IRON AND STEEL TRADES.—Judged by the figures in the annual report of the British Iron Trade Association, the iron and steel industries of Great Britain during 1904 were far from satisfactory. General dulness prevailed throughout the first eight months of the year, and at its close decreases were evidenced of 248,000 tons in pig iron, 159,000 tons in steel of all kinds, and 14,000 tons in puddled iron. It is true that an increase took place in the production of open-hearth steel, but this was more than counter-balanced by a decrease in Bessemer steel. The exports of iron and steel in 1904 were 298,000 tons less than those of the previous year, and as a set-off the imports were 376,000 tons less, although materially greater than in 1902. A satisfactory feature is to be found in the decreased importation of manufactured products, notably of rails, girders, and other rolled sections. Besides having to contend with a period of depression, our iron and steel makers have had to encounter the growing competition of other countries, including various British possessions. There was, in 1904, a noticeable tendency on the part of small States to develop home iron industries. Several Danubian principalities have started blast furnaces and steel works, while Chile, Brazil, and Peru, are exploiting the iron trade in South America. India, Canada, Australia, and South Africa have also entered the lists as competitors. Taking into account the activity of the chief industrial countries, it is easy to understand why the British iron and steel trades showed no buoyancy during the past year.

THE ELECTRIC POWER BILLS.—Since the publication of our last issue one more rebuff has been administered to the London County Council and other would-be monopolists, by the approval of the Administrative County of London Electric Power Bill, and the Bill of the Metropolitan Electric Supply Company. London now stands a fair chance of receiving current for power purposes at rates that should do much to facilitate and encourage manufacturing industries. A very curious circumstance is that while the County Council were busily occupied in trying to burke one measure destined to do much good, they forgot to enter objection to the other equally beneficial enterprise. The Metropolitan Electric Power project relates to a area in the west of London equal to more than half that covered by the scheme of the Administrative County company in the east, and the proposed powers for the supply of electricity are practically the same in each Bill. One result of this oversight is that the Metropolitan Power Bill has been passed without the restrictive clauses imposed upon the Administrative County project. The circumstance shows that strenuous opposition has a real influence upon the mental attitude of Parliamentary Committees, or perhaps its effect is merely to suggest compromise as an easy way of settling difficulties. But we cannot see why the objections of a trading body should be seriously considered. A steel-making company, an engineering firm, or a consulting engineer cannot stop competition in his own district, town, or street, and there is no reason for allowing privileges to trading municipalities which are denied to individuals.

Recent Practice in Refuse Disposal.

By W. FRANCIS GOODRICH.

WHILE the Royal Commission on Sewage Disposal continues to investigate the problem of sewage treatment and disposal with a view to making some definite recommendations thereon, progress is steady in the final and sanitary disposal of the solid waste—the refuse.

While investigating sewage disposal the Royal Commission have been wisely looking into the disposal of solid refuse in so far as combined sewage and destructor works are concerned, as also the cremation of sewage sludge, and the writer was recently invited by the Royal Commission to give evidence on these subjects.

Sewage sludge cake would at first sight appear to be very unpromising material for disposal by fire, containing as it does from 55 per cent. to 80 per cent. of moisture, but such material is nevertheless being burned successfully. This being so it is very remarkable that in the case of hundreds of towns in this country, refuse frequently of excellent calorific value is still accumulated, sometimes to the extent of thousands of tons per annum. Exposed to the atmosphere, often in close proximity to houses, it is generally regarded as a menace to public health and as being entirely out of harmony with twentieth century civilisation.

Fig. 1 is reproduced from a diagram prepared by Dr. Nash, the Medical Officer of Health for the Borough of Southend. Each spot indicates a house where a death has occurred during a comparatively short period, due to the contamination of food by flies from the refuse tips on the brickfields, entering the houses through the open windows. We are sometimes told that the fly is Nature's scavenger, but nevertheless the responsibility of dipterous insects in the dissemination of disease has been fixed again and again. Dr. Thresh, the eminent bacteriologist and County Medical Officer of Health for Essex, recently told the writer that many cases similar to that here referred to at Southend had come under his notice.

It may be said, what has this to do with "Recent practice in Refuse Disposal?" To which we would reply that the refuse of such a popular holiday resort as Southend is still tipped at the brickfields shown in the centre of Fig. 1. Is it not amazing that such conditions can be found in the case of a large and well known health resort, and is it possible to justify such procedure in a town of the size and character of Southend?

Many times has the writer been severely criticised for pointing out the disease-spreading properties of the common fly, but when it is possible for a distinguished Medical Officer of Health to prepare such a diagram as Fig. 1, the writer may perhaps be excused for smiling at the observations of the electrical press concerning flies.

For about thirty years past the disposal of refuse in refuse destructors has been making steady progress. During the past decade remarkable progress has been made, mainly due to a widespread desire for sanitary progress and a keen appreciation of the reproductive aspect of refuse disposal by reason of the valuable amount of power available from the combustion of waste. It is curious that practically every advance made in combustion engineering has been initiated in Lancashire, and so we find that the first refuse destructor was erected in Manchester about twenty-nine years since by the late Mr. Alfred Fryer. The first six cells installed at the Water Street Depôt of the Manchester

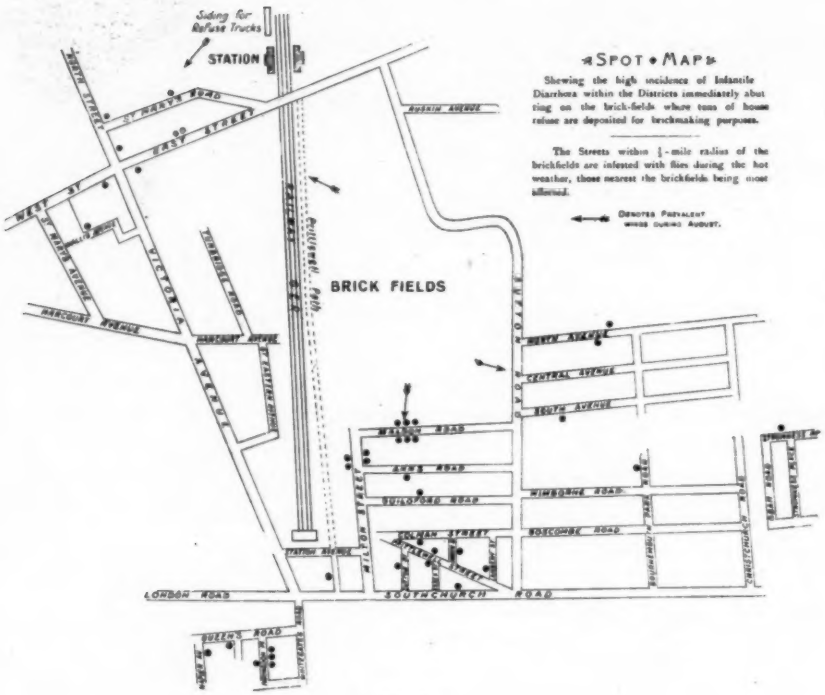


FIG. I.

Corporation are illustrated in Fig. 2, and it is worthy of note that these cells are still in operation. About three years ago Meldrum's Forced Draught was adapted to these cells, as also to a second battery of six cells which were erected in 1878, so that not only are the original British destructors still in operation, but what is more, they are far more efficient than any refuse destructor even yet erected in the United States.

There can be no doubt that the excellent results obtained in power production have counted for much in the widespread adoption of refuse destructors, and while we have no desire to belittle the ever increasing demand for the highest sanitary efficiency, it is beyond all question that the power aspect of refuse disposal has been a powerful factor.

Those who are deaf to the demands of sanitary science have frequently become staunch advocates of the destructor when conversant with the reproductive aspect.

At the present time refuse destructors are in operation in about 220 cities and towns in Great Britain, and those who still continue to dispute the fuel value of civic waste are brought face to face with the fact that in no less than 110 towns in the United Kingdom the available power is being fully utilised for electrical purposes, sewage or water pumping.

In the course of our remarks, we shall be able to show what is actually being done in a number of combined destructor, electricity, sewage and water works, and it will doubtless come as a revelation even to many engineers that a *net* profit is shown even in connection with several

destructors combined with sewage and water works. Figs. 3 and 4 serve to illustrate to what extent the use of coal has been displaced by refuse in about 100 combined undertakings in this country. While electrical engineers may continue to dispute the value of combined works there can be no doubt that in thus displacing coal the ratepayers have benefited. This, after all, is the real consideration, departmental profits may possess more interest for the individual controlling the department but that course which is of collective benefit is the only satisfactory course to adopt.

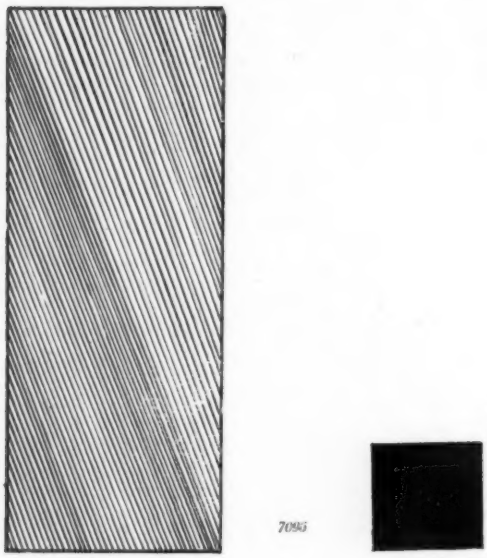
Unfortunately some few electrical engineers still oppose the combination of destructors with electricity works: firstly, because they consider that their department should benefit financially as the result of the combination—a view which is naturally directly opposed to that of the sanitary department. Hence it is a most difficult matter to arrange for payments between the two departments on an equitable basis.

Secondly, the electrical engineer doubtless feels when the destructor is under his control that the authority saves the wages of a destructor superintendent, while offering him no extra remuneration whatever. Doubtless this is a serious grievance and one which should be redressed, and those who operate combined undertakings should certainly receive extra remuneration for such services as they are compelled to render in connection with the final and sanitary disposal of refuse. The writer is of opinion that if this matter received the attention which it merits, the attitude of electrical engineers would change, and that among the members of this profession would be found many of the staunchest advocates of combined undertakings.

During the past year some remarkable figures have been quoted in connection with combined electricity and destructor works. So far as the writer is aware, in no case have these figures been certified by the electrical engineer, while in many cases they have been arrived at by calculation on a basis which is disputed by the responsible official, and questioned by many others competent to judge. To exaggerate the power-producing capabilities of the destructor, either inadvertently or otherwise, is much to be deplored. Calculated results are apt to mislead, and may certainly be counted upon to give offence to those responsible for the operation of the plant.

Moreover, such satisfactory results are being obtained under a great variety

FIG. 2.—THE FIRST DESTRUCTOR: WATER STREET DEPÔT OF THE MANCHESTER CORPORATION.



REFUSE, 1,000,000 TONS = COAL, 100,000 TONS

DESTROYED PER ANNUM AT COMBINED DESTRUCTOR AND ELECTRICITY WORKS.

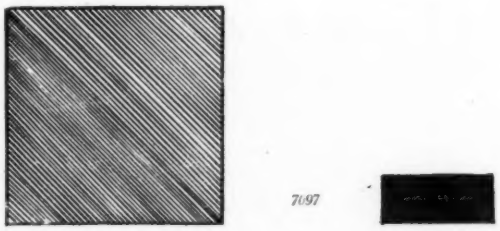
FIG. 3.

of conditions that there is neither necessity nor excuse for misrepresentation or exaggeration by the destructor maker or any one else. All test figures included in this article, as also all figures of electrical output, are officially certified. The writer desires to make this perfectly clear, because some of the results here quoted are distinctly in advance of any returns yet published.

Those intimately concerned with the combustion of low grade fuels have been well aware for a long time past that an electrical output of one hundred Board of Trade units per ton of refuse destroyed could readily be obtained, always providing that the steam consumption per unit generated be kept within reasonable limits. The comparative efficiency of any destructor as a power-producer must be determined on the basis of evaporation per pound of refuse destroyed. It is idle to submit that one destructor is more efficient than another because the electrical output per ton of refuse destroyed is higher. Fair comparison is absolutely impossible unless it is clearly shown (1) how many pounds of refuse have to be destroyed to generate each unit of electricity, or (2) the number of pounds of steam required for the generation of each unit.

At the present time there is a disposition to regard test figures generally as of little value, notwithstanding the fact that many tests are now conducted under actual working conditions, the number of men employed, and the rate of wages paid being the same as under normal conditions. While it is quite true that a record of results over an extended period affords the most useful guide as to the economic value of a plant, yet a properly conducted and complete test serves a useful purpose and possesses far more value than many are disposed to admit.

Following the title of this article, the writer purposes to briefly describe some of the most modern destructor installations combined with electricity works.



REFUSE, 400,000 TONS = COAL, 40,000 TONS

DESTROYED PER ANNUM IN DESTRUCTOR COMBINED WITH SEWAGE AND WATER WORKS.

FIG. 4.

As the largest plant of its kind in the world, the Preston Corporation destructor is of more than passing interest, embodying several unique features of a most useful character.

It is of the Meldrum Regenerative Front Fed type, comprising four units each having four grates, the total grate area of each unit being 100 square feet. All four units are arranged in single row, each unit comprising the destructor, and is a most valuable feature. Condemned carcases can thus be destroyed whole without any handling whatever, thus eliminating all risk and meeting the requirements of the Board of Agriculture.

Special means are also provided for the rapid and easy disposal of offal, abbator and other objectionable waste, which can be tipped direct from its receptacle through a shoot on to a dished firebrick hearth. The noxious gases,

FIG. 5.—VIEW OF DESTRUCTOR HOUSE, STOKE-ON-TRENT.

combustion chamber, Lancashire boiler 30 ft. long by 8 ft. in diameter for a working pressure of 200 lbs. to the square inch, as also a regenerator or continuous air heater, supplying air heated to a temperature of from 300° to 400° Fahr. to the steam jet blowers for the forced draught air supply.

A novel arrangement of slinging and traversing gear is provided for lifting the top cover of the combustion chamber and also for slinging therein carcases direct from vehicles. This is controlled by one man from the tipping platform, as distilled, must then pass over and thoroughly mix with the high temperature gases passing from the large grate area of the destructor cell.

The available steam power is fully utilised for electric traction purposes, and the whole of the car service in Preston is operated from the destructor plant alone, the coal-fired boilers not being required. About sixty tons of refuse are destroyed daily, considerably more steam being available therefrom than can be utilised for traction purposes.

About twenty cars are in service, one

300 k.w. set being in use for about seventeen hours, the total electrical output being about 3,000 units per day, the maximum demand being 400 k.w. and the average load throughout the day about 170 k.w. The following figures,* covering a period of ten weeks, are of interest :—

UNITS GENERATED FROM STEAM SUPPLIED BY DESTRUCTOR BOILERS.

Week ending	January	4th, 1905	= 15,503
,,	,,	11th, ,,	= 17,323
,,	,,	18th, ,,	= 16,307
,,	,,	25th, ,,	= 17,825
,,	February	1st, ,,	= 19,427
,,	,,	8th, ,,	= 19,127
,,	,,	15th, ,,	= 19,934
,,	,,	22nd, ,,	= 20,368
,,	March	1st, ,,	= 19,944
,,	,,	8th, ,,	= 19 975

The following details of the official test further serve to show what can be done with a well-designed plant, and it is but fair to observe that, had superheaters been installed, the efficiency would have been materially increased:—

PRESTON DESTRUCTOR AND TRAMWAY POWER STATION.

Result of Test carried out on One Unit (No. 2), April 5th, 1905.

Type of plant.	Meldrum's Simplex Regenerative Refuse Destructor.	
	Number of grates .	4.
	Total area	100 sq. ft.
	Boiler, Lancashire	30 ft. × 8 ft.
	,, heating surface.	986 sq. ft.
Results ...	Guarantee	40 tons in 24 hours.
	Refuse destroyed in 24 hours.	66 tons, 19 cwts.
	Water evaporation from and at 212° per lb. of refuse.	1·7.
Observations	Duration of test ...	8¾ hours.
	Total refuse fired during test.	24 tons 8 cwt. 1 qr. = 54,684 lbs.
Refuse.	Total refuse fired per hour.	6249·6 lbs.
Clinker ...	Total weight of clinker, 30·3%.	16,576 lbs.
Ash... ...	Total weight of ash from below grate, 2·9% refuse fired.	1,624 lbs.
Flue gases ...	Carbonic acid. continous samples.	12·13 %.
	Oxygen	6·46 %.
	Carbonic oxide ...	·15 %.
Flue temperature.	Combustion chamber (average by working indicator).	2,288° F.
	Combustion chamber (maximum).	2,700° F.
	Downtake (average)	1,310° F.
	Side flues (average)	861° F.
Air and draught.	Temperature of air entering regenerator.	60° F.
	Temperature of air leaving regenerator.	470° F.
	Ashpit pressure (average).	2·8 in. of water.
	Suction draught at chimney base.	·75.
Feed water ...	Delivered to boiler per hour.	8,857 lbs.
	Temperature of feed to boiler.	220° F.
Steam ...	Gauge pressure ...	166 lbs. per sq. in.
	Absolute pressure...	181 lbs.
Economiser...	Greens	288 tubes.
	Weight of feed entering per hour	8,857·1 lbs.
	Temperature of feed entering.	50° F.
	Temperature of feed leaving.	220° F.
	Temperature of flue gases entering economiser.	648° F.
	Temperature of flue gases leaving economiser.	320° F.
Deductions ...	Weight of refuse fired per sq. ft of grate per hour.	62·49.
	Feed water evaporated per lb. of refuse.	1·41.
	Equivalent evaporation from and at 212° per lb. of refuse. Boiler and economiser combined.	1·7.
	Electrical output. B.O.T. units.	2,446.
	Electrical output, B.O.T. units, per hour.	279·54.
	Electrical output B.O.T. units, per ton of refuse.	100·24.

* The writer is indebted to Mr. W. H. Tittensor, the Electrical Engineer to the Preston Corporation, for permission to publish the above figures.

With a similar, but much smaller plant, at Nelson Corporation Combined

FIG. 6.—END VIEW OF ONE DESTRUCTOR, STOKE-ON-TRENT.

Electricity and Destructor Works, the following remarkable results were obtained over a five weeks run under normal working conditions. It is interesting to compare these figures with those of Preston, as they tend to clearly show that such test figures are not necessarily misleading as is so frequently alleged.

RESULTS OBTAINED DURING FIVE WEEKS' RUN OF REFUSE DESTRUCTOR, NELSON.

2nd January to 4th February, 1904.

Furnaces containing 100 sq. ft. Grate area heating one Lancashire boiler, 30 ft. × 8 ft.
Weight of refuse destroyed, 781 tons, 16 cwt. 2 qrs.
Weight of refuse destroyed, 1,751,288 lbs.
Water evaporated, 337,612 gals. = 3,376,120 lbs.
" " per lb. of refuse actual, 1·927 lbs.
" " per lb. of refuse from and at 212° F., 2·12 lbs.
Average temperature of feed water entering boiler, 150° F.
Average steam pressure, 130 lbs.
Destructor steam blowers open, 391 hours.
Steam supplied to electricity works, 346 hours.
Mortar mill running, 100 hours.
Electricity generated, traction 25,099 units,
Electricity generated, lighting, 7,700 units,
Total, 32,799 units.
Electricity generated, per ton of refuse (average including banking), 42 units.
Electricity generated, maximum per ton of refuse, 104 units.
Electricity generated, per hour of steam supply (average), 94·8 units.
Electricity generated, per hour of steam supply, (maximum), 208 units.
Water measured through Kent's Absolute Hot Water Meter.

N.B.—Besides the power supplied to the Electric Light and Power Station as above, the Destructor provided steam for Disinfector, Baths and Lavatories, Pumps, Steam Kettle and Cooking Pans, Clothes Drying Closet, Hot Water to Stables, Steam Heating of Provender Room and Disinfector Buildings.

When exceptionally good results are shown in connection with a particular combined works, it is often observed that the conditions must have been specially favourable, and various reasons are adduced, many of which are more ingenious than logical, to account for the successful results obtained. There

is a constant desire to discount or explain away any results which stand out above the average, and it is for this reason that we have included records obtained under a variety of conditions in a number of combined works.

The following figures from the Burnley Combined Electricity and Destructor Works will possibly be of interest. The destructor at Burnley is practically the same as that at Nelson, the only difference being in the arrangement of the plant in so far as the relative positions of the cell and boiler is concerned.

BURNLEY CORPORATION COMBINED ELECTRICITY AND DESTRUCTOR WORKS.

Record of Refuse Destroyed and Water Evaporated therefrom for 13 weeks ending June 25th, 1904.

Refuse weighed in tons.	Water evaporated in lbs.
183	818,780
179	781,480
207	748,260
178	679,140
188	692,460
212	647,800
211	638,100
190	617,000
210	655,400
181	626,800
212	614,500
221	799,200
266	960,300

In each of the above weeks except the last, the water evaporated is for six days, in the last case it is for seven days.

The water was measured by means of a Kennedy hot water meter, and for several weeks was checked by an automatic recorder on a 6 in. by 25 in. Weir pump. The meter was certified by the makers as being in thorough order and registering correctly.

At Burnley, as at Nelson and Preston, the power is fully utilised for electric traction purposes, an average electrical output of about sixty units being obtained per ton of refuse destroyed.

It is only possible to show such figures

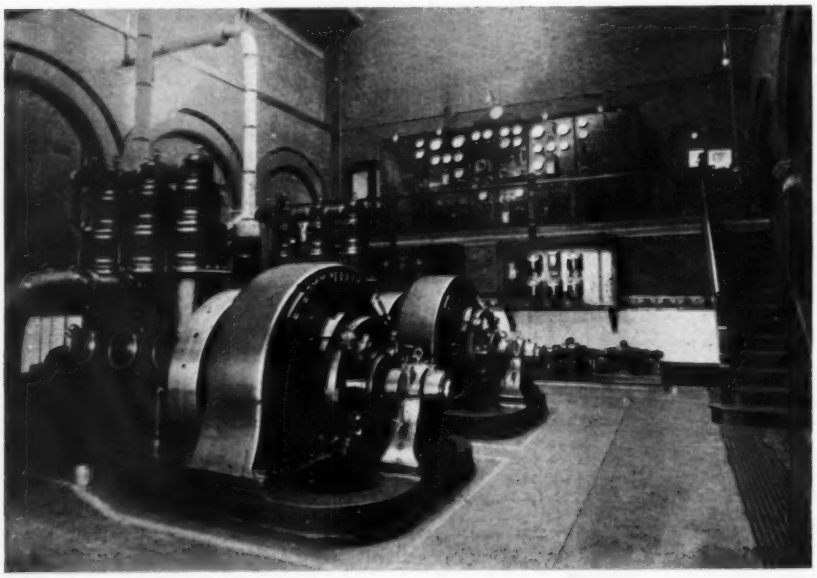


FIG. 7.—STOKE-ON-TRENT DESTRUCTOR WORKS; GENERATING PLANT.

as these in connection with combined works where the available power is fully utilised, but such results are by no means confined to large works. The writer recently visited the combined works of the Cleckheaton Urban District Council, where the average weight of refuse destroyed daily is only about twelve tons. Here, again, the power is utilised for traction purposes, and Mr. A. Pickersgill, the electrical engineer, told the writer that no difficulty was experienced in obtaining an average electrical output of from sixty to seventy units per ton of refuse destroyed.

While a very satisfactory day motor load for power purposes is being developed in connection with some of the combined undertakings in London, unfortunately a traction load is not likely to be secured in any district. Having in mind that the main output in every case is for lighting purposes and must necessarily develop in this direction, it must be admitted that very good work is being done.

At the Plumstead combined undertaking, belonging to the Metropolitan Borough of Woolwich, owing to the character of the load, which is practically a lighting load only, the refuse is destroyed between the hours of 4 p.m. and midnight. Under these conditions the maximum value is obtained from the refuse, and the electrical output per ton of refuse destroyed is remarkably good, varying from fifty to sixty units per ton during the summer, to seventy to one hundred units per ton during the winter months.

The following table has been compiled from the last official figures available in connection with the combined undertakings controlled by the metropolitan boroughs of Fulham, Bermondsey, and Hackney respectively.

YEAR ENDING MARCH 31, 1904.

		Fulham.	Bermondsey.	Hackney.
1.	Capital expenditure... ...	£25,227	£25,885	£41,236
2.	Quantity of refuse destroyed in tons ...	£32,554	£13,027	£39,175
3.	Greatest quantity destroyed in one day. Tons	130	60	189
4.	Smallest quantity destroyed in one day. Tons	70	30	38
5.	Average quantity destroyed daily. Tons...	106	37	128
6.	Total weight of clinker, ash, and flue dust. Tons	9,361	6,051	17,418
7.	Revenue from supply of steam to electricity department ...	£2,086	£500	£2,362
8.	Wages of workmen	£3,225	£1,769	£3,611
9.	Wages of workmen per ton of refuse destroyed ...	23·8*d.*	32·6*d.*	22·1*d.*
10.	Repairs and maintenance cost	£363	£525	£467
11.	Repairs and maintenance cost per ton of refuse destroyed ...	2·7*d.*	9·7*d.*	2·9*d.*
12.	Management expenses per ton of refuse destroyed ...	6·1*d.*	3·4*d.*	1·5*d.*
13.	Interest on loans per ton of refuse destroyed.	5·2*d.*	15·4*d.*	6·6*d.*
14.	Sinking fund per ton of refuse destroyed ...	8·9*d.*	17·7*d.*	5·2*d.*
15.	Total revenue...	£3,566	£887	£2,514
16.	Total expenditure	£6,968	£5,586	£7,344
17.	Balance being net cost to public health department for destruction of refuse ...	£3,402	£4,699	£4,830
18.	Ditto, ditto, per ton of refuse destroyed ...	25·1*d.*	86·6*d.*	29·6*d.*

Separate detailed statements such as the foregoing should be available in

connection with every combined undertaking in the country. Generally speaking at the present time the accounts are presented in such a form that it is all but impossible even for an expert statistician to ascertain the actual financial position of both the electricity and destructor works. It is but fair to the ratepayer that separate and intelligible accounts should be rendered, and it is to be hoped that ere long steps will be taken to force those responsible for the present muddle to abandon their methods and to present a separate and clear financial statement for every municipal undertaking.

One of the latest combined electricity and destructor works is that at Stoke-on-Trent. It is interesting to note that although these were opened about nine months since, no coal fired boilers are installed and up to date the whole electrical output has been generated from refuse.

The destructor is of the Meldrum Regenerative Front Fed type, comprising two 3 grate destructors, two Lancashire boilers, each 30 ft. by 8 ft. for a working pressure of 160 lbs. to the sq. in., Patent Regenerators for heating the air supply for combustion and Green's Economisers. The plant is arranged in two separate units, each unit comprising one 3 grate destructor, spacious combustion chamber, Lancashire boiler and regenerator, the economiser being so arranged that either of both of the destructors may discharge their gases through the same or direct to the chimney by means of the usual bye-pass flue. The arrangement for the charging of offal into the destructors is the same as that already described in connection with the plant at Preston. The clinker is removed in skips, slung on an overhead rail, instead of being wheeled out in barrows. That part of the clinker railway outside of the destructor building is shown in Fig. 5. An end view of one destructor is seen in Fig. 6., while Fig. 7 shows the generating plant.

The following detailed figures of the official test disclose what the writer believes to be the highest recorded results in evaporative efficiency and electrical output yet shown in any combined undertaking, and it is worthy of note that these figures are certified by Mr. P. J. S. Tiddeman, the Borough Electrical Engineer.

STOKE-ON-TRENT COMBINED ELECTRICITY AND DESTRUCTOR WORKS.

Destructor Test, February 15th to 16th, 1905.

Type of Plant.	Meldrum's Simplex Regenerative Refuse Destructor (Front Feed).	
	No. of cells, 3; total grate area.	75 sq. ft.
	Type of boiler (Lancashire 30 ft. × 8 ft.) heating surface, 1,050 sq. ft.	No cones.
Economiser...	Greens, 192 tubes.	1,920 sq ft. H. S.
Duration of Test.	Commenced 11.15 p.m., February 15, 1905; finished 2 p.m., February 16th, 1905.	14¾ hours.
Refuse ...	Total amount of refuse delivered, including pots, tins, &c., 28 T. OC. 2 Q. =	62,776 lbs.
	Amount of pots, tins, &c., not destroyed, 7 cwt. 1 qr. =	812 lbs.
	Total amount of refuse destroyed.	61,964 lbs.
	Total amount of refuse destroyed per hour.	4,200·9 lbs.
	Total amount of refuse destroyed per sq. ft. of grate per hour.	56 lbs.
Clinkering...	Average time occupied to clinker each grate.	5·3 minutes.
	Number times clinkered each grate.	15.
	Total weight of clinker.	17,304 lbs.
	Percentage of clinker to refuse consumed.	27·9 %.
Ashpit Pressures.	Average	1·5 in.
	Maximum	3·0 in.
Temperature of Gases.	Average in combustion chamber.	2,500°.
	Average in boiler downtake.	1083 73° F.
	Average in boiler side flues (before regenerator).	687·4° F.

STOKEONTRENT COMBINED ELECTRICITY AND DESTRUCTOR WORKS—*continued.*

Temperature of Gases—continued.	Average after regenerator and before economiser.	426·1° F.
	Average after economiser and before chimney.	289·0° F.
Vacua. ...	Average pull in boiler sides flues, $\frac{11}{01}$ in. =	·171 in.
	Average pull before regenerator, $\frac{23}{03}$ in. =	·359 in.
	Average pull at chimney base, $\frac{37}{04}$ in. =	·579 in.
Steam Pressure.	Average pressure...	143·66 lbs.
Water ...	Temperature of feed entering tank (before softening) average.	50·58° F.
	Temperature of feed entering economiser, highest 100°, lowest 70°, average.	85·27° F.
	Temperature of feed leaving economiser, highest 255°, lowest 193°, average.	216·5 F.
	Total amount of water evaporated (per meter).	141,486·7lbs.
	Total amount per hour.	9,592·31.
	Equivalent of water evaporated by boiler.	125,190·20.
	Equivalent of water evaporated by economiser.	16,296·5.
	Water evaporated per sq. ft. of heating surface in boiler per hour.	8·0 lbs.
	Water evaporated per sq. ft. of heating surface in economiser per hour.	·57 lbs.
	Economiser duty...	11·5 %.
	Amount of water evaporated per lb. of refuse (including economiser).	2·28 lbs. actual.
	Amount of water evaporated per lb. of refuse from and at 212°.	2·66 lbs.
Air Conduit	Temperature of air entering regenerator.	59° F.
	Temperature of air leaving regenerator (maximum).	276° F.
Electrical Output.	Total output in units or k-w. hours.	2,991·3 k.w. hours.
	B. O. T. units per hour (average).	202·8.
	Units per ton of refuse.	108·1.

Some extraordinary results are also recorded in connection with Water and Destructor Works.

Curiously enough in connection with Combined Destructor and Sewage Works or Water Works, very clear accounts are available and the writer is pleased to be able to say that almost invariably Surveyors and Municipal Engineers are able to render financial statements and also general records such as would satisfy the most inquisitive and exacting individual.

The following table will serve to show what is actually being done in a number of such works, and it will possibly come as a revelation to many that several of these are actually financially reproductive, showing a fair net surplus in relief of the rates.

British destructor practice is one long record of progress standing out in strong contrast to the continuous record of failure in America. During the past few weeks the writer has had an opportunity of discussing American practice with some of the most eminent American sanitary engineers, and it is freely admitted by them that there is but little hope of the refuse disposal problem in America being solved until British destructors are adopted. Those who are distinctly opposed to their adoption endeavour to justify their action by constantly directing attention to the difference between British and American refuse, regardless of the fact that British destructors are successfully dealing with refuse of a most varied character in many countries.

In Christchurch and Auckland, New

COMBINED DESTRUCTOR—SEWAGE AND WATER WORKS.

A. Name of Town.	B. Weight of refuse destroyed daily.	C. Actual labour cost per ton of refuse destroyed.	D. Annual repairs and maintenance costs.	E. Annual saving in fuel.	F. Additional annual revenue other than saving in fuel cost.	G. Capital expenditure on Destructor and Steam raising plant.
Aldershot ...	14	9*d.*	Total, 1*s.* in 5 years.	£350.	£218.	£1,200, excluding boilers and chimney.
Bolton ...	*48	10*d.*	£14	£234.	—	—
East Ham ..	30	1*s.* 7·7*d.*	—	£1,000.	—	£12,600 inclusive.
Eccles ...	28	†11½*d.*	Nil in 1½ years.	£350.	£400.	£4,500, boilers and chimney excluded.
Epsom ...	10	11*d.*	Nil in 1¼ years.	£370.	£186.	£4,510 inclusive.
Hereford ...	10	1*s.*	Total in 8 years, £34.	£400.	—	£800, boilers and chimney excluded.
Leamington	35	—	£15.	£183.	—	£6,310, excluding chimney only.
Luton ...	23	1*s.* 3½*d.*	—	Estimated £500.	—	£5,000, approximately excluding chimney and one boiler.
Lytham ...	12	8*d.*	Total in 3 years, £3 6*s.*	£272.	£70.	£2,400 inclusive.
Newmarket	10	—	—	£225.	£75.	—
Sheerness ...	12	1*s.*	Total in 2½ years, £1 10*s.*	‡Net Annual Saving. £443 10*s.* 4*d.*		£3,425, excluding chimney only.
Taunton ...	20	8½*d.*	—	£118 16*s.* 7*d.*	—	£4,000 inclusive.
Waltham-stow ...	*60	1*s.*	—	£650.	—	£9,000 ,,
Watford ...	25	§1*s.* 4*d.*	Nil in 1¼ years.	‡£783 18*s.* 2*d.*	£101 3*s.* 9*d.*	£6,800 ,,
West Bridgford ...	10	1*s.* 6*d.*	Total in 1½ years, £10.	£150.	£17.	£5,600 ,,
Weymouth	18	11*d.*	Total in 1½ years, £2 10.	‡£376.	‡£309.	£4,000, excluding chimney and one boiler.

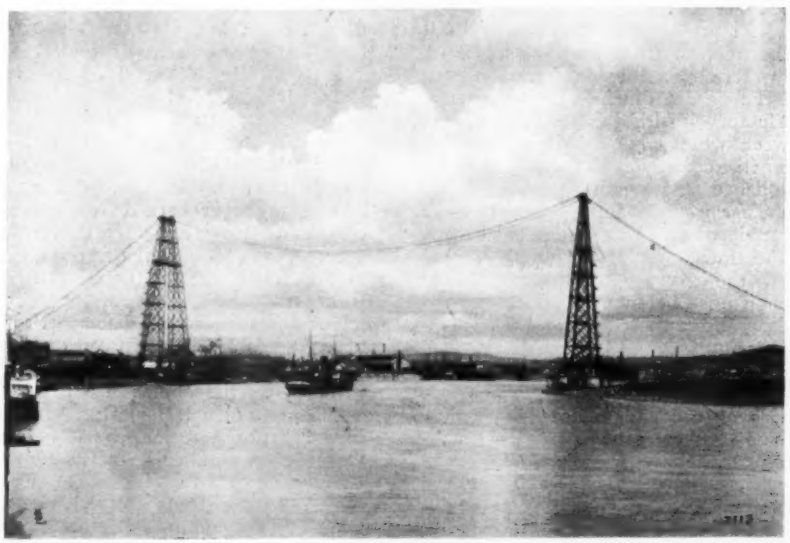
* Two-thirds refuse, and one-third sludge.
‡ For 1904.
† Including flue cleaning.
§ Including supervision and management.

Zealand, British destructors are not only successfully disposing of the refuse but are also supplying power for electrical purposes, this is also being done in Johannesburg and at Kalk Bay-Muizenberg, the rapidly developing Brighton of Cape Colony. British destructors are also doing good work in Bloemfontein, Durban, Lorenzo Marques, at Pernambuco and Buenos Ayres in South America, at Calcutta, Toowoomba (Queensland) Annandale (New South Wales) in Germany, Denmark and Switzerland. Those destructors which can be designed to efficiently destroy such a variety of waste as is produced in these countries might well be adapted to meet American requirements. Unsatisfactory as it may appear to many of our American kinsmen, the time is quickly approaching when it will be possible to add their country to the sphere of progress in final and sanitary refuse disposal on British lines.

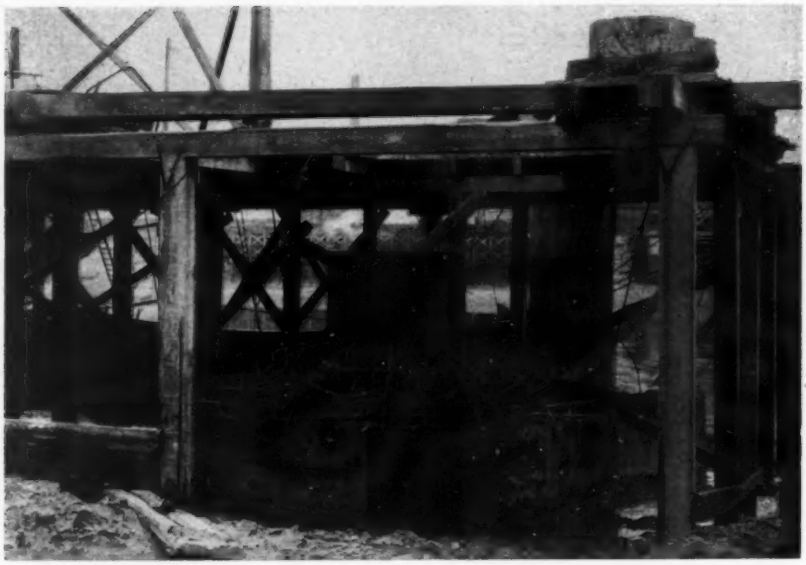
Newport Transporter Bridge.

ALTHOUGH the Widnes and Runcorn bridge across the Mersey and Manchester Ship Canal has the distinction of being the first of the "transporter" type in this country (and outside the Continent), to be opened for public use, the idea of the transporter bridge, which is under construction at Newport, Monmouthshire, was mooted several years earlier than the one connecting the Palatine counties of Lancashire and Cheshire. The problem of crossing the river Usk had long engaged the attention of the Newport authorities before a transporter bridge was accepted as the solution. The borough really consists of two distinct towns, the old occupying the western, and the new the eastern bank of the river, and the latter has for many years been steadily extending in a southerly direction. At present, the only means of access between the old and new towns is a stone bridge of five arches, built in the year 1800, which was widened in 1866, and again widened and otherwise remodelled in 1882-3. These works still left the old bridge in a far from satisfactory condition, in fact, it would be impossible to make a good job of the structure, which dates from a time when Newport comprised a handful of houses, clustered around a castle. With the enormous growth of the town the question of additional cross river communication had to be faced. The inhabitants in the south of the old and new portions respectively, although separated by a channel only 200 yds. in width, have to travel 3½ miles to reach each other.

The Usk is no ordinary river. The



THE NEWPORT TRANSPORTER BRIDGE



NEWPORT TRANSPORTER BRIDGE. FOUNDATION SHOWING METHOD OF FORMING WORKING CHAMBER.

velocity of the current is great; it is noted for the extraordinary rise and fall of the tide, 40 ft. at high springs; the low water channel is extremely shallow; and the nature of the banks very unsatisfactory. Although the exact points between which a new bridge or cross-channel communication should be established was a matter for debate, it was a *sine quâ non* that it would have to be provided to meet the southerly growth of the town, that is, nearly two miles below the existing bridge, and some little distance below the most important docks and quays.

Therefore, from shipping having to be reckoned with, the choice of the authorities was restricted to a ferry, subway, high level bridge, or "movable" bridge scheme. A ferry was deemed impracticable owing to the above-named characteristics of the river, while the estimates furnished for the erection of a high level bridge, and "movable" bridges of varying types revealed that the cost of each would be enormous—as much as £1,250,000 for a high level fixed bridge, and £700,000 for a swing bridge, to give but two examples.

In 1896, Mr. Robert H. Haynes, the Borough Engineer, proposed a transporter bridge, as a result of a visit he had paid to the first transporter ever constructed at Bilbao, which had been opened in 1893. The complete novelty of the proposal earned for it hostile criticism. However, Mr. Haynes persevered. In 1898, owing to the remarkable development on the eastern bank, it became a question of urgency to adopt some definite scheme. Projects of all kinds were again prepared and considered, including a transporter. Eventually, the choice rested between a subway and a transporter. In 1899, Mr. Haynes escorted a party of the Corporation officials and Harbour Commissioners to Rouen, to inspect M. Arnodin's transporter across the Seine. The committee were so impressed by that experience, that they at once and unanimously declared

themselves in favour of Mr. Haynes's project. Mr. Haynes and M. Arnodin were appointed engineers, and the bill for the construction of the bridge received parliamentary sanction in the session of 1900. Tenders for the work were obtained in the summer of 1902, and the works were begun in the early autumn. The chief dimensions are as follows.—

Span, centre to centre of towers, 645 ft.
Span between faces of piers, 592 ft.
Clear height to underside of stiffening girder from high water mark, ordinary spring tides, 177 ft.
Height of tower from pier cap or level of approach road to saddle, 241 ft. 6 in.
Distance between centres of anchorages, 1,545 ft.
Centre of tower to centre of anchorages, 450 ft.

The accompanying photographs give an excellent idea of the construction of the bridge, which it is hoped will be completed five months hence.

The foundation piers, eight in number, are placed in groups of four on each bank. On the west shore their foundations are carried down 78 ft. below the river bank, and on the east shore to a depth of 86 ft., owing to the upper surface of the marl, reached at a depth of 68 ft. below high water mark, proving somewhat softer than the borings revealed. The central spacing between piers is 78 ft. 9 ins. on the riverward faces, and 36 ft. on the faces at right angles thereto. Although some of the tenderers suggested steel cylinders in preference, each pier consists of a monolith mounted on a steel shoe 20 ft. in diameter. The monoliths were sunk by compressed air working. The towers are of open steel construction, and their general outline looking in the direction of the stream is an even taper from base to summit, while viewed from across the stream the legs are spindle shaped. The upper part of the tower above the platform is rigidly connected together by three tiers of lattice girders and heavy bracing, the ordinary bracing in each leg being carried up in addition, so as to make the whole head of the tower thoroughly

EAST ANCHORAGE, NEWPORT TRANSPORTER BRIDGE.

firm; the extreme top is heavily reinforced by joist sections, in order to take and distribute the weight transmitted to the saddles and their expansion carriages; and below the platform level the legs, though well stiffened by gussets and brackets, are not connected in any way, the space between being required for the passage of the car and parts of its suspension ropes. On the top of each masonry pier a heavy cast-iron saddle is fixed, carrying a rocker, on which rests an inverted saddle connected to the tower leg itself. This arrangement ensures perfect elasticity, together with direct vertical reaction through the monolith. Each leg is secured to its spindle by steel shackles, and each spindle to the masonry pier by steel bolts and clips. Each tower is fitted with an easy stairway from the ground to the platform level, and it is proposed to net in the stairways, and allow the public to ascend to the platforms for a small fee.

The estimated weight of a tower is 277 tons, and in their erection a very simple electrical crane has been employed. Equipped with one motor, rotating in but one direction, the various motions of lifting the load, canting and rotating the jib, and traversing the crane, can be obtained simultaneously. Further, the crane has this unique feature—it can be rotated through a whole circle. The capacity is three tons at 25 ft. radius. In addition to the 277 tons of steel work in a tower, there are about 100 to 150 tons of timber used in staging and scaffolding. The actual expenditure of current used in Board of Trade units for lifting the whole of this material is 598.

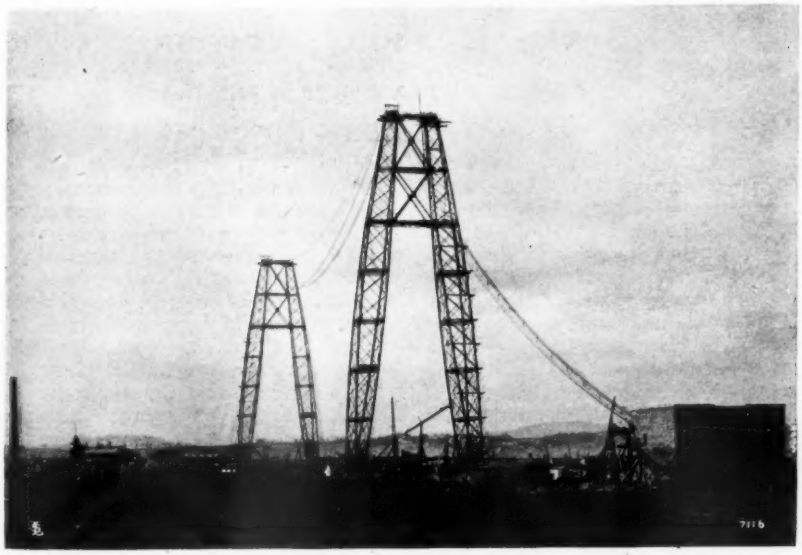
The anchorages are of rubble masonry on a pile and lime concrete foundation, and galleries are provided for the passage of the cables, which thus can be inspected throughout their length. The reaction is taken through granite bed blocks, having armoured cement concrete blocks on their inner faces.

There are sixteen suspension cables, each cable being composed of 127 wires of 20 millimetres in area; and sixteen anchor cables, each composed of 127 wires 21·7 millimetres in area. These cables are secured at their ends to cast steel sockets, which are in turn connected to the main saddle pins of the expansion carriages by shackles of high resistance steel, and a similar arrangement holds good at each anchorage. Consequently, it is possible to renew cables in detail without suspending the working of the bridge.

A portion of the span is carried by diagonal cables, and the horizontal force developed by these is taken by the parabolic cables attached to the ends of the rail-carrying girder. Each of these latter cables is built up of ninety-one wires of 18·54 millimetres sectional area. The stiffening girders run the whole length of the platform, and are placed 26 ft. 3 in. apart axis from axis, their depth being 16 ft. The bottom boom is the rail carrying girder on which the traveller runs. Both top and bottom boom are provided with a series of cleats and steel shackles, threaded by steel pins, which are suspended from the parabolic cables by iron rods, pins, and stirrups, and connected to the diagonal cables by shackles. The pins form articulations, on which the verticals merely rest and the diagonals engage. This arrangement eliminates any distortion or strain, and renders the whole structure solid though flexible. In order to prevent the compression of the top boom (under either the influence of a load or great variation of temperature), exceeding the calculated tension, it is fitted in three places with elastic joints, which allows the girder to follow the movement of the suspension cables.

The travelling frame, running under the bottom boom of the stiffening girders, measures 104 ft. in length by 26 ft. in width. It is furnished with sixty cast-steel wheels, carried in steel brackets fixed to the longitudinal members of the frame, and arranged as follows:—fifteen inside and fifteen outside the web of each of the rail carrying members, and fifteen pairs of horizontal wheels engaging on the edge of the flange plate.

The transporter car is suspended from the traveller by thirty ropes, set in



A VIEW OF THE NEWPORT TRANSPORTER BRIDGE LOOKING N.W.

triangulation, to prevent any excess of swaying during high winds.

The car is 33 ft. in length by 40 ft. in width, and weighs 31·5 tons. It is divided into a central roadway space, which can take six two-horse vehicles, and covered footways on either side, accommodating three hundred passengers. The motorman's cabin, containing the controlling apparatus, is on one side.

Electricity is the propelling power, but the motors are not geared to the traveller as at Runcorn. The principle is that of a winding engine, *i.e.*, the frame is propelled by steel wire ropes wound on a drum, worked by motors fixed on the shore at the western end.

The car at rest does not project into the river, but is housed in a dock at the base of the tower; the riverward face of each dock being furnished with an elastic buffer, which will absorb the momentum of an incoming car, and accelerate the start of an outgoing one. The rate of travel will be 10 ft. per second, so that the crossing will occupy little more than a minute.

The following contracts have been let to Mr. Alfred Thorne, of Westminster:—foundation piers and anchorages, £23,897; shore abutments, eastern pier, and lattice girder span, £4,588; steel superstructure and travelling apparatus, £35,165.

Dover Harbour Works.

By W. NOBLE TWELVETREES, M.I.Mech.E.

WITH the disappearance, some five hundred years ago, of the small haven which formerly existed at the eastern extremity of the bay, Dover, the principal cinque port of England, was left without a harbour for ships. King Henry VII. may be regarded as the founder of the present harbour at the western end of the bay, and Henry VIII. as the first to inaugurate engineering works on a really extensive scale. Successive improvements effected by the Corporation of Dover and the Harbour Board created by James I. brought the works in the year 1838 to the state of development generally indicated by Fig. 1, and in 1847 the first step towards the creation of a great national harbour was taken by the commencement of the Admiralty Pier. In 1861 the control of the harbour was transferred to the existing Harbour Board, which consists of the Lord Warden of the Cinque Ports, and representatives of the Corporation, the Admiralty, the Board of Trade, and the South Eastern and Chatham Railway. The new board speedily justified their existence by the construction of the Wellington and Granville docks on the site of the previously existing basins, and on the completion of the Admiralty Pier in 1871 to the length of 2,100 ft., the harbour had been developed to the condition shown in Fig. 2.

A few years later the gates of Wellington Dock were widened 10 ft. to admit Channel steamers of greater size than formerly employed, the slipway was lengthened by 40 ft., and widened for the accommodation of vessels up to eight hundred tons burden. These and other improvements were followed in 1891 by the inauguration of a comprehensive scheme involving an expenditure of £700,000 for the construction of a new commercial harbour with a water area of fifty-six acres and a depth of 40 ft. at low water. Subsequently, the area was increased to seventy-five acres.

This project deserves special mention as the most important undertaking proposed for the development of Dover Harbour since the time of Henry VII., and it shows that the Harbour Board had thoroughly grasped the advantages possessed by Dover as the nearest port to the Continent, as a place of call for shipping, and as the only safe deep water harbour on the coast between Harwich and Portsmouth.

By the Dover Harbour Act of 1891 the Board were empowered to execute the following works:—

(1) The construction of a pier to the east of the original entrance to the harbour, this work comprising an open iron viaduct 1,260 ft. long and a solid masonry pier 1,500 ft. long, this length being increased to 1,920 ft. at a later date.

(2) The construction of two landing jetties each 100 ft. wide by 1,100 ft. and 500 ft. long respectively.

(3) The reclamation of five acres of land between the south entrance and the Admiralty Pier and the erection thereon of a covered marine station.

(4) The extension of the Admiralty Pier for 580 ft. eastwards.

These works were commenced in 1893 and were to have been completed by the end of 1901, but owing to the reawakened interest of the Government in the national harbour scheme, some modifications became necessary, and as a matter of fact the final details have only just been settled by agreement with the Lords Commissioners of the Admiralty. The general scope of the new commercial harbour as projected in 1891 is shown by Fig. 3.

Fig. 4 is a plan of the entire works as proposed by Sir John Coode in 1903,

and although the details of the Commercial Harbour Scheme have been modified since that date, the chief features of the National Harbour remain practically unaltered.

As contemplated by the Act of 1897 the national harbour was to include a water area of 610 acres with a maximum depth of 42 ft. at low water; the estimated cost was £3,500,000, and the time of construction ten years.

The works were commenced in 1898 and the following are the chief operations comprised in the scheme:—

(1) The extension of the Admiralty Pier east south-east for a distance of 2,000 ft., the total height of the pier from base to parapet being about 90 ft.

(2) The construction of an east pier, or arm, projecting 3,000 ft. into the sea.

(3) The construction of a sea wall 3,850 ft. long between the Castle jetty and the foot of the new east pier.

(4) Reclamation of land between the new sea wall and the base of the cliffs.

(5) The construction of an island breakwater 4,300 ft. long between the Admiralty and East Piers, providing an entrance 600 ft. wide at the east, and one 800 ft. wide at the west.

Coaling berths are to be provided for about 1,800 ft. along the inner side of the East Pier, and three powerful forts will be built to strengthen the defences of the new naval base.

Theoretically, the national harbour and the commercial harbour are two entirely separate concerns, as the Admiralty and the Harbour Board are two distinct organisations. But practically, the two harbours taken together constitute Dover Harbour, a view which finds ample support in the amicable relations that have always existed between the Admiralty and the Harbour Board. For many years past the use of the Admiralty Pier has been permitted for the erection of landing stages for Channel steamers and as the site of a railway station, and within more recent times, transatlantic steamers have been permitted to lie alongside the outer face of the Commercial East Pier, now designated the Prince of Wales Pier, being therefore in the national harbour. Moreover, all vessels entering or leaving the commercial harbour must necessarily pass through the national harbour.

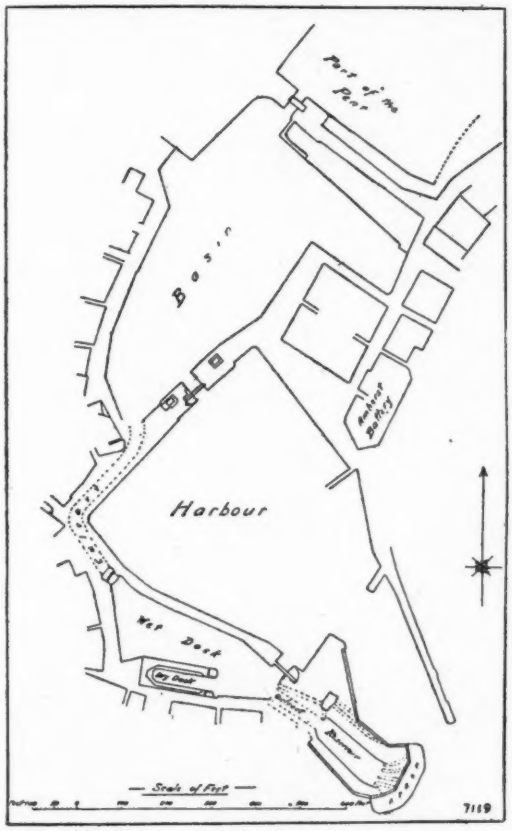


FIG. 1.—DOVER HARBOUR IN 1838.

From the foregoing it is evident that the projection of the national works commenced in 1899 necessarily involved

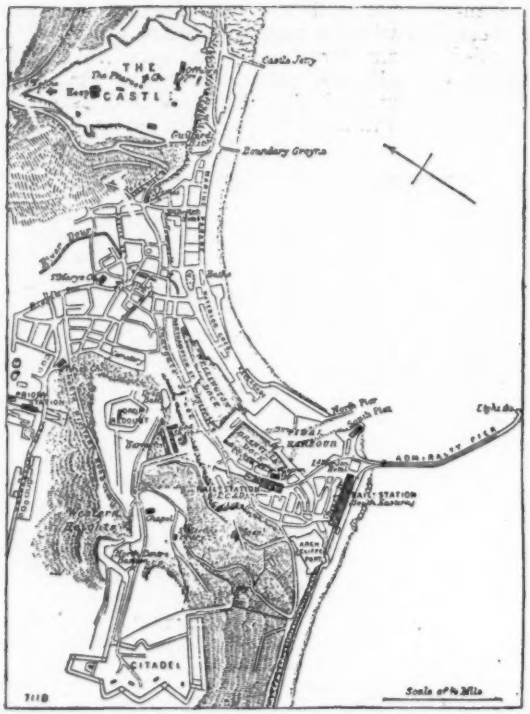


FIG. 2.—DOVER HARBOUR IN 1871.

some modification in the scheme of the Harbour Board, the most noteworthy alteration being that the extension of the Admiralty Pier was transferred to the Government undertaking. The Prince of Wales Pier and approach viaduct have been built and other incidental works executed, but the remaining portions of the 1891 scheme have been kept back with the object of insuring perfect co-operation with the aims of the Admiralty.

We now propose to describe and illustrate the works mentioned, and for the sake of convenience will deal with them under two distinct heads:

(1) The Commercial Harbour Works and (2) the National Harbour Works.

In conclusion we shall give full particulars of the works which the Harbour Board have recently decided to carry out for the completion of their undertaking.

(1) *The Commercial Harbour.*—All the works included in the scheme of 1891 were designed by the late Sir John Coode, the working details having been added by his successors Messrs. Coode Son and Matthews. The first of the new works to be undertaken was the Prince of Wales Pier, the contract being let to Sir John Jackson, Limited, at the price of £414,000, but owing to the decision to increase the length of the pier an additional expenditure of some £200,000 became necessary, or about £614,000 in all.

Operations were commenced in 1892 upon the approach road which is of very substantial construction, being carried on concrete walls with a facing of granite. The shore end of the pier proper is a steel viaduct 1,260 ft. long consisting of a series of short girder spans supported on mild steel piles arranged in bays spaced 40 ft. apart, the separate piles in each set being connected laterally with mild steel bracing.

The platform is at the height of 18 ft. above high water level and is about 30 ft. wide. By the adoption of pile supports for this portion of the pier it was thought that the consequent circulation of currents in the harbour would have an important influence in checking the deposition of silt, thereby reducing the cost of dredging.

This viaduct was built for the contractors by Messrs. Head Wrightson & Co., of Stockton-on-Tees. At the time this structure was designed the Prince of Wales Pier was intended to be the eastern breakwater of the new

harbour, and it is by no means improbable that an open viaduct of the kind would have permitted far too much disturbance of the enclosed water area. However, as the pier in question has now become an inner pier, owing to the construction of the national harbour, no trouble of the kind need be anticipated.

Beyond the seaward end of the steel viaduct, the pier is continued to the length of 1,920 ft. in solid concrete having a facing of Cornish granite. The concrete was deposited in the form of blocks weighing from ten tons to twenty tons each. The blocks were moulded in a yard established by the contractors near the shore end of the pier whence they were transported to the site on a temporary railway and lowered by means of travelling cranes to the required position. The necessary excavation in the bed of the sea was performed by Hone's grabs, made by the Civil Engineering Department of the Thames Ironworks.

After the foundation had been roughly prepared by grab-dredging, the surface was levelled by men lowered to the bottom in diving bells of special construction and lighted by electricity. Then the setting of the blocks was performed by men in diving dress. The whole of the concrete block work was securely keyed and dowelled together so that the completed structure is practically monolithic. The pier has a width of only 30 ft. at the top which is by no means adequate in view of developments that have taken place since the works were first planned.

As we have already stated, the commencement of the Admiralty works made it desirable for the Harbour Board to reconsider the original plans for the construction of the jetties and marine station. Moreover, the extension of the Admiralty Pier was naturally transferred from the commercial to the national harbour scheme.

Several plans have been prepared for the Harbour Board since 1899, relative to the completion of their general scheme. In one plan the two jetties were replaced by a substantial pier; a railway line proceeding from the South Eastern station crossed the reclamation and passes across a viaduct to the Prince of Wales Pier; and the present tidal harbour was converted into a dock.

A second plan, reproduced in Fig. 5, shows the Prince of Wales Pier widened to the extent of 250 ft. and provided with a railway station of ample dimensions connected with the South Eastern system as mentioned above; and the interior of the commercial harbour was kept entirely free from inner jetties or piers.

In view of the uncertainty prevailing

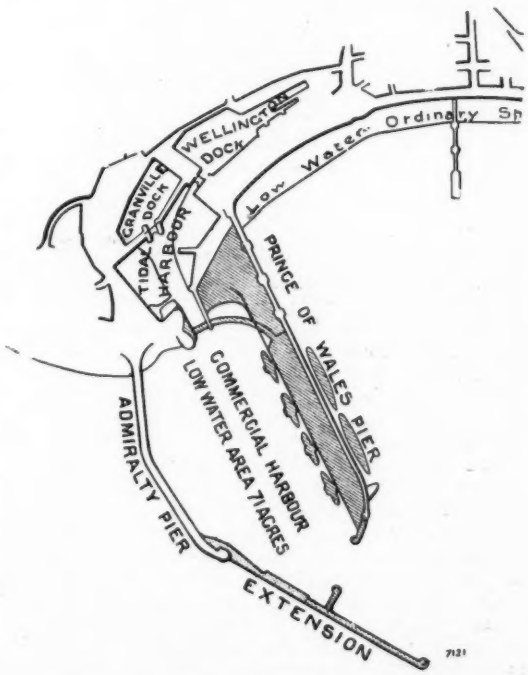


FIG. 3.—THE COMMERCIAL HARBOUR AS PROJECTED IN 1891.

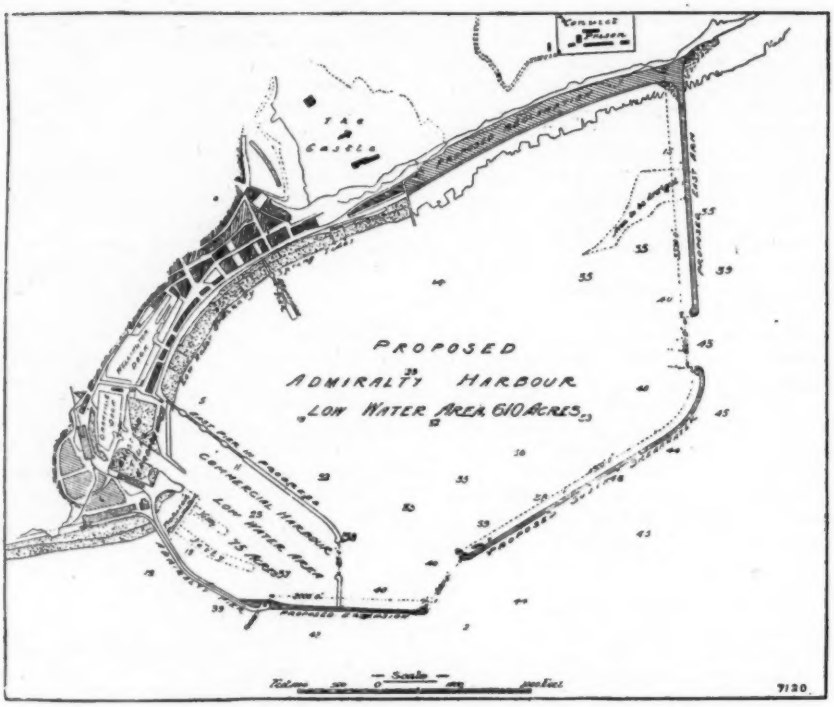


FIG. 4.—DOVER ADMIRALTY HARBOUR AS PROPOSED BY SIR JOHN COODE.

as to the final outcome of the Admiralty scheme, and of the certainty that the ultimate decision would not be arrived at for some years, the board wisely elected to make the utmost use of the facilities so far available in the interests of the travelling public. In the prosecution of this policy they have received valuable assistance from the Admiralty.

One of the first privileges accorded by that department was permission for the building of a new landing stage on the Admiralty Pier providing double the accommodation of the other stages and affording greater protection for vessels during the prevalence of south-westerly gales. Subsequently, for the purpose of dealing more efficiently with Royal mails, parcels, and passengers' luggage, two electric cranes were installed on the same pier. Cases of special design have been provided for use in connection therewith, so that mail bags, parcels, and luggage, may be transferred in bulk from railway to steamer and *vice versa*. The cases are of such size that three of them are carried by one railway truck made with a flat platform like that of a lorry. Fig. 6 is a view showing one of the cranes in the act of hoisting a case from the steamer. Each crane is designed for dealing with loads up to 4 tons at a maximum radius of 55 ft. and is provided with hoisting, slewing, derricking, and travelling motions. The jib has the unusual length of 60 ft., and is of very light construction so as to offer as little resistance as possible to the wind. The gauge of the rails is 10 ft., and the

net weight of each crane is 53 tons. The electrical equipment includes a 37 b.h.-p. Siemens motor running at 420 revolutions per minute for hoisting, and an 18 b.h.-p. motor running at 310 revolutions per minute for the three other motions. Both motors are operated by a "Universal" controller which enables the attendant to control all the motions by the manipulation of a simple handle. Two brakes are fitted to the hoisting gear of each crane, one being automatic and operated by an electric magnet, while the second is applied by a foot lever. Both cranes were built to the specification of Mr. A. T. Walmisley, M.Inst.C.E., Engineer to the Dover Harbour Board, by Messrs. Grafton & Co., of Bedford, and the electrical equipment was furnished by Messrs. Siemens Brothers & Co.

It may be added that special provision has been made for slewing against the wind and that the hinder part of each crane house has been carried back for a sufficient distance to balance the jib and thus to permit the use of the cranes in the roughest weather.

Turning now to the development of the Prince of Wales Pier, it must be pointed out that the building of this structure left a very large amount of work to be performed under the direction of the harbour engineer. The most pressing requirement was to equip the new pier suitably for the reception of Transatlantic and other large steamers desiring to make Dover a port of call. The most important works were the construction of a landing stage more than 500 ft. long on the east side of the pier for the reception of ocean steamships and the building of a temporary port-of-call railway station. The latter, which was erected by Messrs. S. Pearson & Sons to the plans and under the direction of Mr. Walmisley, is 500 ft. long and among the various buildings

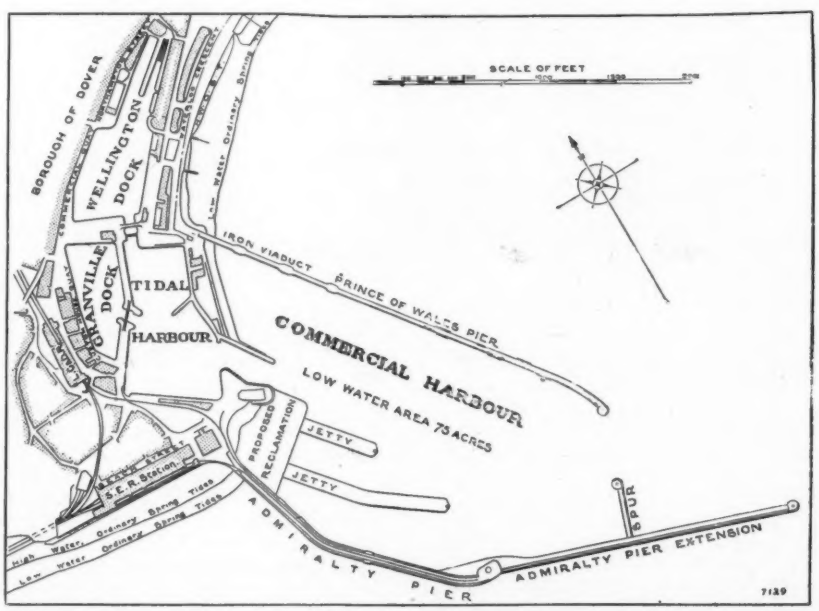


FIG. 5.—DOVER HARBOUR, WITH EXTENSION PROPOSED IN 1891.

are a large temporary waiting room, refreshment and cloak rooms, and offices occupied by the various steamship and traffic companies interested in the passenger traffic of the port.

Direct communication with the railway system of Great Britain is afforded by a new branch railway. Starting from a junction in the Harbour Station of the South Eastern and Chatham Railway Company, this line proceeds to end. In approaching the pier from the esplanade the gradient is 1 in 30, and on passing from the steel viaduct to the solid masonry portion of the pier the gradient is 1 in 40. The chief feature of interest in connection with the new line is the electrically operated hydraulic swing bridge across the Wellington Dock entrance.

The bridge comprises two steel girders 134 ft. 11½ in. long, spaced 17 ft.

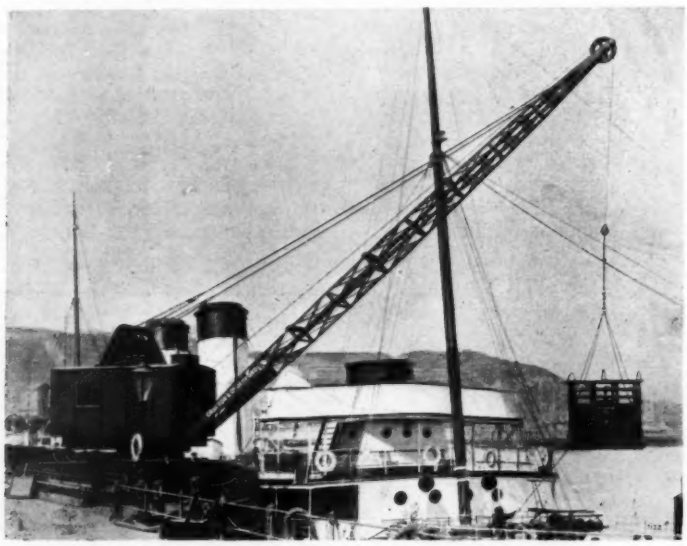


FIG. 6.—ONE OF THE ELECTRIC CRANES, ADMIRALTY PIER, DOVER.

along Strond and Union streets, across the entrance to the Wellington Dock by a new swing bridge, passes across Cambridge-road and the esplanade, and along the Prince of Wales Pier to the new port-of-call station.

This railway, as well as the station, was built by Messrs. S. Pearson & Sons in the short period of six months, an achievement due in no small measure to Mr. W. C. Hawke, the engineer who has been in charge of the Admiralty Pier extension contract from beginning apart and connected by transverse tracing and a decking of Karri with blue gum treads, steel tracks for the wheels of vehicles, and rails for the Prince of Wales Pier line. On the western side a cantilever path, 4 ft. 11 in. wide, is provided for foot passengers. The span is carried by a hydraulic pivot so as to form two cantilevers, one 91 ft. 1½ in. long and the other 43 ft. 10 in. long. The pivot rests upon a block of granite embedded in a mass of concrete 6 ft. 6 in. square in plan, which in turn

is supported by the solid chalk 22 ft. below.

Power is furnished by an electric motor, operating a 12 in. hydraulic ram, which pushes an accumulator to the top of the adjoining tower, a height of 45 ft., the accumulator being loaded with 29 tons of ballast. This gives a hydraulic pressure of 750 lb. per sq. in. for operating the bridge. Before the bridge can be swung it has to be raised about 3 in. by the hydraulic pivot so as to clear the bearings. Having been lifted the outer end cants up slightly, as the other end is loaded with iron ballast cast from material furnished by the old bridge. The swinging of the span is effected by the aid of a 16 ft. ring, to which a heavy chain is attached. This chain has to be hauled for a length of about 12 ft. to cause the quarter turn required for opening the bridge, and being passed over a sheaf is connected to a hydraulic ram with a stroke of 6 ft., which, as the chain is doubled, gives the requisite movement. The operations of opening and closing can easily be performed within 5 minutes. The bridge was designed by Mr. Walmisley, having been built and erected by Messrs. Armstrong Whitworth & Co., of Elswick.

On completion of the bridge and railway last year a Board of Trade inspection was conducted by General Hutchinson, the test load consisting of two 90-ton locomotives. On this occasion the deflection of the bridge under the weight of two locomotives was found to be only 0·36 in. and that of the viaduct, where the spans are less than half the span of the bridge, was only 0·24 in. These results are extremely satisfactory and sufficiently indicate the strength and rigidity of the structures in question.

Mention must also be made of some other appliances recently applied on the Prince of Wales Pier for ministering to the convenience of passengers and for expediting the mooring of vessels and the handling of merchandise.

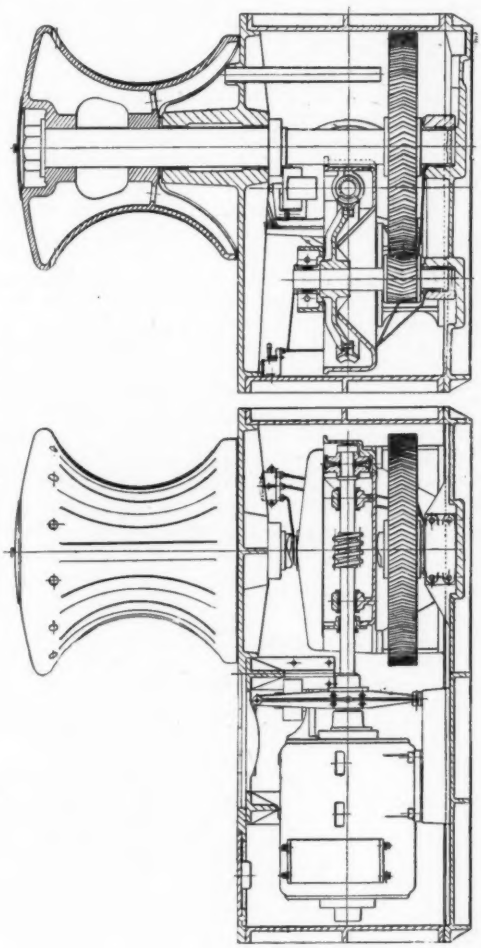


FIG. 7.—SECTIONAL ARRANGEMENT OF 15 TON ELECTRIC CAPSTAN.

The first of these is an ingenious gangway devised by Captain Iron, the harbour master of Dover, to get over the difficulty of landing passengers from

the lofty decks of Atlantic liners now making Dover a regular port of call. Owing to the tidal range, the decks of these vessels are more than 20 ft. above quay level at high tide, and it will readily be understood that in view of the narrow space available no ordinary gangway could be employed at such times. The new gangway consists of a telescopic tower to the platform of which the upper end of a long gangway is attached in a direction parallel with the face of the quay. The upper end is hinged and the lower end is fitted with wheels so that it readily accommodates itself to any position of the rising and falling platform. The height of the platform is adjusted to correspond with that of the vessel alongside, and provision for the passage of passengers is then made by a short gangway which is always in a horizontal position. As the other gangway is of considerable length the angle assumed is never inconvenient, and as no motion can be communicated by the movement of the vessel the descent presents no terrors to the most timid of travellers.

The entire apparatus is mounted on wheels running on a track countersunk into the quay roadway, and the hoisting of the tower is performed by worm gear, at present operated by hand.

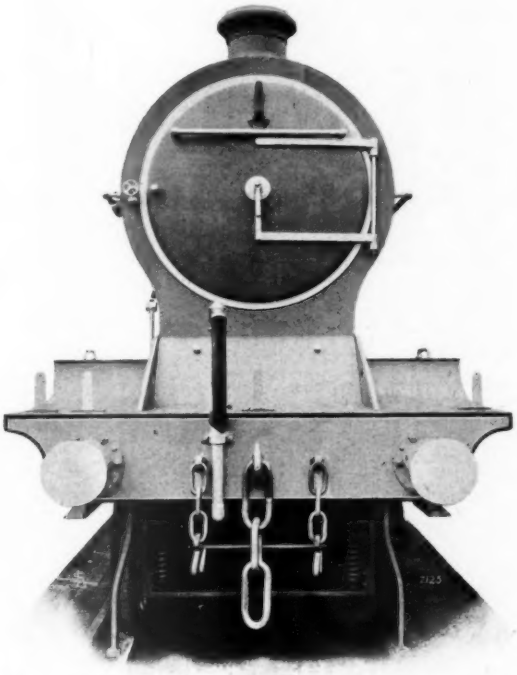
Among the most recent equipment of the pier are several 15-ton electric capstans made by Messrs. Clarke Chapman & Co., of Gateshead. Fig. 7 is a section showing the general arrangement of this type of apparatus. The barrel is driven by a 38 b.h.-p. electric motor through a combined worm and spur gear. The worm gear is enclosed in an oil bath and the spur gear is of cast steel with machine moulded teeth. All the working parts are readily accessible for examination and repair by means of hinged doors.

The capstan is of very massive design and in every way suitable for dealing with the Hamburg-American Red Star and other liners which are now making regular use of the new pier.

This brief account completes the category of works executed up to the present time for the development of the Commercial Harbour of Dover, but after describing some features of the larger undertaking, we shall direct attention to the programme settled by the Harbour Board as the result of recent negotiations with the Admiralty.

The New Compound "Atlantic"-type Express Passenger Locomotive of the Great Northern Railway.

ALTHOUGH not one of the largest, in point of mileage, the Great Northern is one of the most important of Britain's railway systems, and whilst its management, from a traffic point of view, is known to be distinctly enterprising, there has also for several years past been a progressive spirit pervading the operations of its locomotive department, as is evidenced (taking merely one example) in the several splendid engines of the well known "251" class of simple "Atlantics," which have during the past few years been built at Doncaster, from the designs of Mr. H. A. Ivatt, M.Inst. C.E., the locomotive engineer of the Great Northern Railway. Whilst these

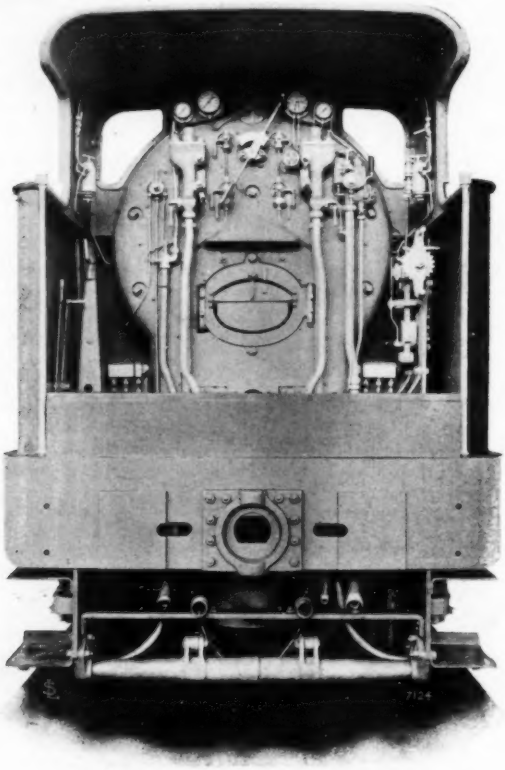


FRONT END GREAT NORTHERN RAILWAY 4-CYLINDER COMPOUND.

"Atlantic" locomotives represent fully 35 per cent. more power than the engines which they replaced, Mr. Ivatt is not altogether satisfied, and the directors, acting on his suggestion, some months ago issued invitations to locomotive builders, specifying the duty to be done, and asking them to build engines—compound or otherwise—for trial on the Great Northern line.

Towards the end of last year, in accordance with the decision of the Great Northern Directorate, a contract was placed by them with the Vulcan Foundry, Limited, of Newton-le-Willows, Lancashire, for a large four-cylinder balanced compound locomotive, to be erected from the designs submitted by them.

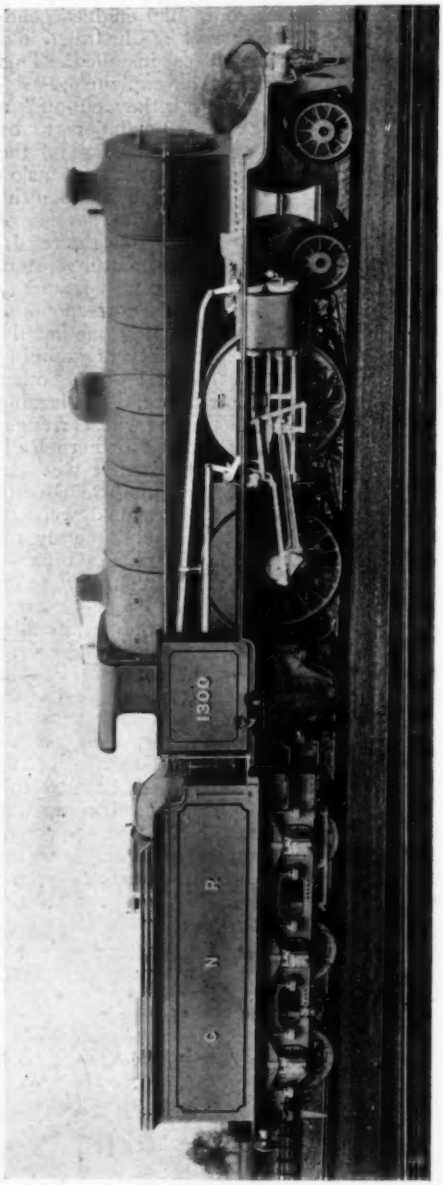
The locomotive has quite recently been completed, and for the accompanying photographs and diagram drawing, illustrating this powerful type of express engine, the writer is indebted to the courtesy of the builders.

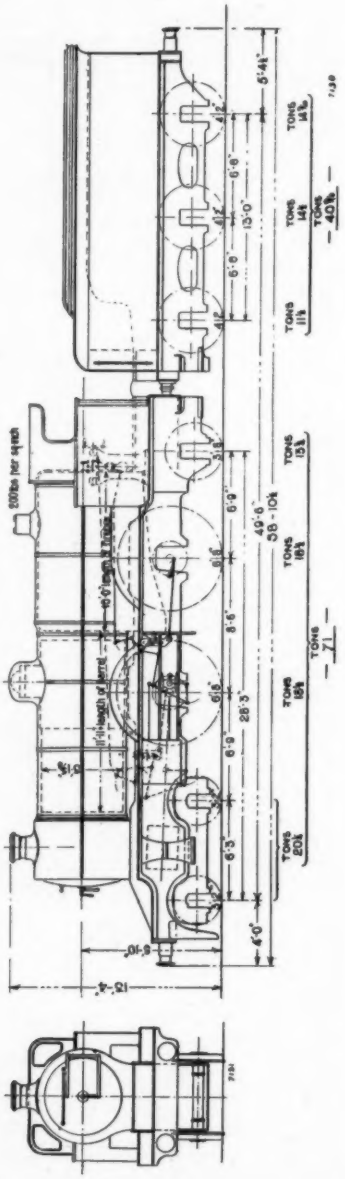


GREAT NORTHERN RAILWAY 4-CYLINDER COMPOUND: BACK END.

As will be noticed from the diagram, the engine is of somewhat unusual dimensions, being not only the largest but the heaviest, locomotive of its type ever erected in Great Britain for service

over a British railway. As the locomotive is now being submitted to exhaustive trials on the main line of the Great Northern Railway, a more detailed description along with the reproduction of sectional drawings will be reserved for another occasion. It may, however, be here stated that the high-pressure cylinders are 14 ins. diameter, with a stroke of 26 ins., whilst the low-pressure cylinders are 23 ins. diameter with a stroke of 26 ins. The bogie wheels are 3 ft. 2 ins. in diameter, the driving wheels are 6 ft. 8 ins. in diameter, and the trailing wheels are 3 ft. 8 ins. in diameter, the total wheelbase of the engine being 28 ft. 3 ins. The boiler is of large proportions, having a barrel 11 ft. 11 ins. in length, with an outside diameter of 5 ft. $1\frac{5}{8}$ ins., its centre line being "pitched" 8 ft. 10 ins. above the rail level. The total heating surface is 2514 sq. ft., to which the tubes ("serve" steel) contribute 2344 sq. ft., and the firebox the remaining 170 sq. ft. The working pressure is 200 lbs. per sq. in. and the grate area 31 sq. ft. The firebox has a length of 10 ft., and its height, as also that of the engine cab, has been restricted on account of the smoke troughs in the running sheds and also the coaling platforms, and, for this reason, a Belpaire pattern firebox, which had been originally designed for this locomotive, could not be utilised. The engine is fitted with the "Vulcan" patent starting valve, designed for the purpose of admitting steam, at a reduced pressure, to the receiver at starting, whilst the "Vulcan" patent screw reversing gear, which has been specially arranged for compound locomotives, but is equally applicable for compound engines generally, and which will be illustrated in a later issue, has been installed. This gear, it may here be explained, is designed so as to permit the "cut-off" in one cylinder, or set of cylinders, to be varied independently of that in the other. This ensures that the expansion shall be reasonably shared between the cylinders, and prevents undue rise of pressure in the receiver, with the resulting stresses on the low-pressure piston. The motion may be reversed from any position in one gear to the corresponding one in the other by moving one handle, and there is no possibility of jamming the screw, as in several of the other arrangements now in use. The leading bogie, as also the trailing wheel arrangement, are of the Great Northern Railway Company's standard types. In running order, the engine (exclusive of tender), as originally designed, weighed 72 tons, but this was subsequently reduced to 71 tons, distributed thus:—on the bogie wheels, 20 tons 5 cwts.; on each of the driving, 18 tons 10 cwts. (this being the maximum permitted by the Great Northern Railway Company), whilst the trailing wheels carry 13 tons 15 cwts. The tender has a fuel space of 5 tons of coal, and a capacity for 3,670 gallons of water, runs on six wheels, each 4 ft. 2 ins. in diameter and weighs 40 tons 18 cwts., so that this new four-cylinder balanced compound "Atlantic" of the Great Northern Railway has an aggregate weight on the rails of no less than 111 tons 18 cwts.





GREAT NORTHERN RAILWAY 4-CYLINDER COMPOUND EXPRESS LOCOMOTIVE.

House Drainage.*

By GERARD J. G. JENSEN.

Flushing.

THE motive power by which fœcal matter is forced through the drainage system being water, it is hardly necessary to point out how essential it is, not only to provide it liberally, but also to utilise it to the greatest advantage.

Leaving out the ordinary tap, which is an obvious but in many cases also a prohibited means of supply, the apparatus made use of for the purposes of flushing may be divided under two heads, viz., automatic and non-automatic appliances. The former of these are intended to discharge comparatively large quantities of water spontaneously at regular intervals of time. They are frequently constructed so that the water is discharged from a vessel which works upon a pivot so placed that the centre of gravity of the tank varies as the water rises, until a condition of unstable equilibrium is set up and the tank tips over, discharging its contents and returning to a vertical position when empty. Such a tank is shown in Fig. 17. More generally, the water is arranged to discharge through a syphon, as, for example, in Fig. 18. The discharge of this type of tank is brought about by the overflow of water into the long leg of the syphon. As the water falls through the latter, a portion of the imprisoned air is carried with it, and a partial vacuum thus formed. The pressure of the water above the cap of the syphon is thereby enabled to overcome that of the air contained in the syphon, and the water in the tank passes out with a rush until its level falls to the edge of the inlet to the syphon, when syphonage will be broken by the admission of air.

One or other of these types of flushing cisterns should be provided at the head of each main drain, as the rapid and powerful discharge of water from them will forcibly eject any deposit which may have taken place in the drain; whilst, at the same time, the renewal of air within the drainage system is greatly assisted. The quantity of water to be discharged must necessarily depend upon the length, diameter and inclination of the drain, and may vary from thirty gallons to as much as two hundred gallons. Forty to sixty gallons is, however, the more usual capacity of flushing tanks necessary for an ordinary house drain, and their discharge should be arranged to take place at least two or three times weekly.

Branch drains need not, as a rule, be automatically flushed if they are laid to self-cleansing gradients, unless they are provided for the conveyance of liquids containing a high proportion of grease, as, for instance, from scullery sinks. The collection of grease by means of grease-traps is very objectionable owing to the very general neglect of its removal. Automatic flushing renders it unnecessary, as by its means the grease is cooled, broken up and carried through the drain without chance of adhesion to the sides of the latter. A thirty gallons tank will be sufficiently large for the purpose if arranged to discharge at least once in twenty-four hours. The best results are obtained by leading the sink waste into a flushing-rim gully-trap and connecting the tank to the waste-pipe, as shown in Fig. 19; provision being made to counteract the tendency to trap-syphonage by the aid of a ventilation pipe.

Although the benefits to be derived from automatic flushing cisterns are

* For previous articles see pp. 679 and 840, Vol. XII.

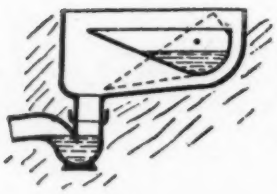


FIG 17.

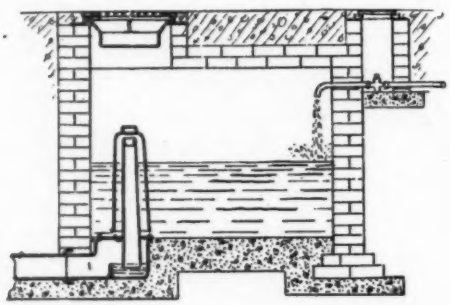


FIG. 18.

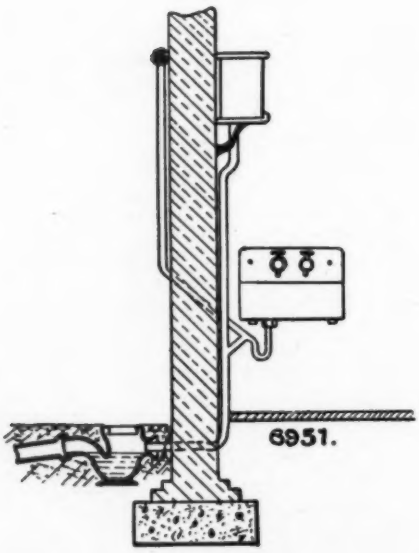


FIG. 19

invaluable when viewed from the standpoint of sanitation, various water companies have raised objections to their use on account of "waste," and have in some cases—notably in London—entirely prohibited their use unless the water is paid for by meter.

Non-automatic flushing cisterns are made use of in the supply of water to water-closets, slop-hoppers, and—as water companies usually prohibit the more efficient automatic appliances—urinals. They are more generally known as "water-waste preventers," and are made in such an endless variety of form that it is not possible to describe them in any detail. The two accompanying illustrations (Figs. 20 and 21) are, however, more or less representative of the two principal types. In the case of the former, the cistern is actuated by raising a valve which can only be momentarily lifted from its seat, but which admits sufficient water to the long leg of the syphon to put the latter in action. The cistern shown in Fig. 21, on the other hand, is actuated by thrusting a body of water over the bend of the syphon.

So long as these cisterns are of reasonably ample capacity and of simple construction, they provide an important adjunct to the sanitary condition of closets, &c., as they do not only economise water, but also ensure a proper flush even though used by the most dilatory of users; for they liberate a stated quantity of water at the least touch. Here again, however, the water companies have intervened and insisted upon a maximum capacity of two-and-a-half or of even only two gallons. This is altogether inadequate, as most of the closets at present existing require a flush of at least three gallons. A two-gallon cistern will, however, suffice for slop-sinks; whilst one gallon is sufficient for an ordinary urinal basin.

In addition to waste-preventing cisterns, there is an appliance (Fig. 22) generally known as a "bellows regulator," which is usually attached to valve closets. Although this is not strictly a "waste preventer," it is nevertheless as

economic as any in general use. It consists of a copper cylinder in which is enclosed a bellows arrangement with a valve at the bottom. Whilst readily admitted to the bellows, when the lever actuating the water supply is pulled up, air can only escape slowly through the small tap shown in the illustration when the lever descends. The supply of water to the closet can, therefore, only be closed off slowly and in proportion to the speed at which the air has been regulated to escape. In this manner the quantity of water to be admitted to the closet can be adjusted.

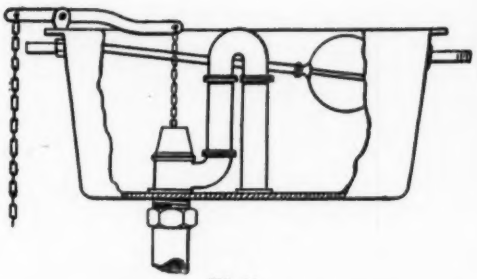


FIG. 20.

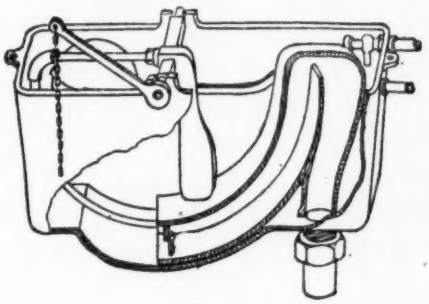


FIG. 21.

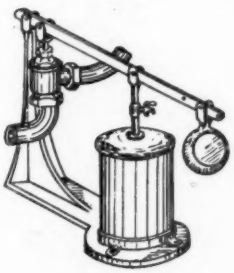


FIG. 22.

Access.

Means of access to the drainage system are desirable in order that obstructions may be reached and removed without expense and inconvenience; for, although a well-constructed system of drainage should not be liable to stoppage by the accumulation of sewage, it is found that floor-cloths, spoons, brushes and other matters, which cannot be removed by mere flushing, will frequently find their way into the drains or their connections. Means of access will also facilitate the very desirable periodical examination and testing of the drains.

As far as possible it should therefore be made a practice to render each pipe and connection accessible throughout.

Underground drains should, with this view, always be laid in straight lines from point to point and have inspection chambers, or manholes, built on all junctions and bends. Two such chambers are shown in section in Figs. 23 and 24. The former, which represents an inspection chamber on stoneware drains, has its bottom formed of half-channel pipes set in cement. Drain air—and, in the event of stoppage, even sewage—having access to all portions of the manhole in a chamber of this type, it is essential that the interior surfaces of the manhole be rendered impervious by being coated with cement or by being built of non-absorbent materials. It is also necessary that the

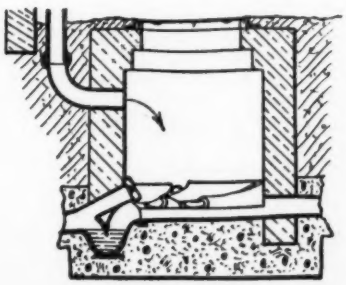


FIG. 23.

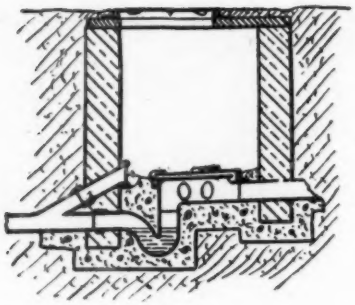


FIG. 24.

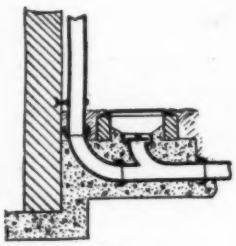


FIG. 25.

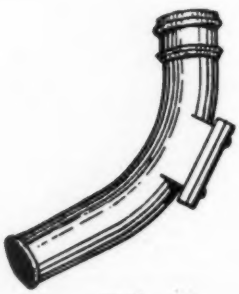


FIG 26.

FIG. 27.

FIG. 28

FIG. 29.

manhole be covered at the ground level by an air-tight, yet removable, cover. In the case of the manhole shown in Fig. 24, which is one built on an iron drain, it will be noticed that the bottom is formed by a cast-iron access pipe fitted with an air-tight lid. These access pipes, which are also available—in a less perfect form—for stoneware drains, have much in their favour, as they confine drain air to a very small portion of the manhole, accelerate direct ventilation, and render it immaterial whether or not the rest of the manhole is air and water tight.

Branch drains which are not otherwise accessible, may be conveniently provided with a "sweeping eye" at their head by the insertion of a junction pipe (as in Fig. 25), or by the provision of a socket on the outlet of the gulley trap, should the branch drain end in such.

Vertical and other piping fixed above ground may be rendered accessible by the insertion of access pipes or caps (of which Figs. 26 and 27 illustrate examples), in convenient positions.

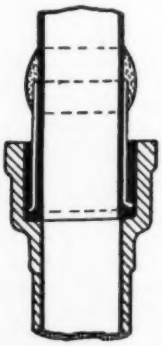


FIG. 30.

If the points so far discussed are carefully attended to, much will already have been done towards preventing the intrusion of foul air into the dwelling-house or its surroundings by avoiding the formation of noxious gases. For the rest, the prevention of leakage is, however, chiefly dependent upon the suitability of the materials and joints made use of in the construction of the drainage system.

Materials and Joints.

The materials available for the construction of the underground drains are practically confined to stoneware and cast-iron. The former are jointed with Portland cement or with a mixture of resin and asphalte; whilst in the case of the latter, the joints are made with lead, poured into the sockets of the piping in a molten state and subsequently thoroughly caulked before it has completely cooled.

Whichever material is adopted, it need hardly be said that the piping made use of must be the best of its kind. It must be straight, true in section, even in the thickness of its walls, and free from all air holes, flaws, and other defects. Its interior surfaces must be glazed and perfectly smooth, whilst the pipe sockets must be strong and sufficiently wide and deep to allow good joints to be made. In the case of cast-iron, the pipes must also be protected against decay by being coated with some anti-corrosive substance, such, for instance, as Dr. Angus Smith's solution, or the protective coating of oxide which is imparted by the Bower-Barff process.

Stoneware pipes were, until recently, almost exclusively used for drainage work and may even now be said to answer admirably for the construction of rain-water drains and such sewage drains as are not near buildings or in positions which render them liable to injury through settlement or vibration. For sewage drains generally—and particularly such as pass under or near buildings, under roads or paths on which heavy traffic is anticipated, or such as are laid in soft, swampy or treacherous ground—cast-iron piping is becoming increasingly used on account of the various advantages which it possesses. The most important of these are:—(*a*) Its superior strength and capacity to resist fracture; (*b*) the facilities which iron piping affords for making strong and reliable joints; (*c*) the long lengths in which the pipes are manufactured; and (*d*) the corresponding reduction in the number of joints. Regarding the two latter, it may be pointed out that iron drain pipes are made in 9 ft. lengths, whilst stoneware drains are usually only 2 ft. long. This fact economises time in the laying of a given length of drain, ensures a straighter and more concentric drain, and avoids a great number of joints, which, seeing that they are necessary evils giving opportunities for imperfections, should be as few as possible. The only objection which can be fairly urged against iron piping —that of additional cost—is more than balanced by the additional security obtained and the longer life of the drain. It is interesting to note that the advantages of cast-iron drains are so well recognised in the United States of America, that, in New York and many other cities, it is compulsory for house drains to be constructed of iron to a distance of 10 ft. on the sewer side of the disconnecting trap; beyond which point stoneware piping may be utilised.

It should be stated that iron drains should not be less than three-eighths of an inch in thickness.

Whichever material is made use of, drains should always be laid upon a firm concrete foundation from four to six inches deep,—according to the nature of the ground in which they are laid,—and not less in width than three times the diameter of the drain pipes. On completion of each section of the drainage system, this concrete should be extended to the sides of the drains as shown in the annexed sketch (Fig. 28), to secure stability; whilst in the case of stoneware drains near or under

buildings, the concrete should be made to surround the pipes completely (as in Fig. 29) to a depth of six inches all round.

Soil pipes are usually constructed of cast-iron or lead. Each of these materials has its advantages and drawbacks when made use of for that purpose. Lead piping, for instance, is smoother and not readily affected by the gases present in domestic sewage and the air of towns, but is, on the other hand, affected by heat and cold, which give it a tendency to "creep," a term by which is understood the gradual downward movement imparted to the pipes by the expansion and contraction which follow variations of temperature. Both materials are, however, good if the piping is of suitable strength and efficiently jointed.

Iron piping should in all particulars fulfil the conditions named for iron drain pipes, although it need not necessarily be quite as strong. One quarter of an inch will be a sufficient thickness for its walls. Lead piping should be of a description known as "hydraulic-drawn" and of such thickness that a square foot of the metal will weigh not less than 8 lbs. This is generally known as "8 lb. lead," and is equivalent to 0·135 inch in thickness. The joints should be those known as "wiped solder joints," of which an example is shown in Fig. 30, which illustrates the proper connection between a lead soil pipe and an iron drain. As will be seen from the illustration, the lead pipe should for this purpose be passed through a brass ferrule; the lead being bent over the lower edges of the ferrule and the pipe jointed to its upper end by means of a wiped solder joint. The ferrule is then inserted in the iron socket and, being rigid and strong, will admit of a caulked lead joint being made in the ordinary way. The connection between a lead pipe and a stoneware drain is effected in a similar manner, except that cement and not molten lead is made use of as the jointing material.

Whether lead or iron is adopted for soil-pipes, it is desirable that lead only should be used for ventilation pipes. As these are not washed by sewage (which of itself protects them against corrosion by imparting to them a greasy coating) they are apt to rust and deteriorate rapidly, through exposure to various gases, if constructed of iron.

For waste pipes from sinks, baths and kindred fittings, lead is the only admissible material. Its substance and the joints of the piping should be the same as those recommended for lead soil-pipes.

Lead piping is also very advantageous for rain-water pipes, but, inasmuch as it is also very costly for the purpose, light iron piping is usually made use of. The pipes should in all cases be galvanised, as the ordinary, unprotected, or painted, iron rain-water pipes are a constant source of annoyance and trouble owing to their choking from internal rust.

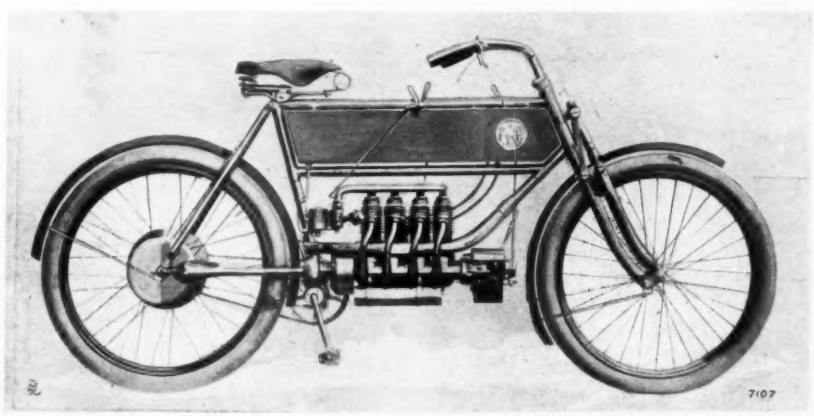
4-Cylinder Motor-Bicycle at the Liége Exhibition.

THIS new motor-cycle, brought out during the present year, is made at the Fabrique Nationale d'Armes de Guerre, Herstal. The object aimed at in the design is not so much a racer, because the management is of opinion that excessive speed tends to bring the motor-cycle into disrepute, but a touring machine of moderate speed that can be depended upon and is not liable to get out of order.

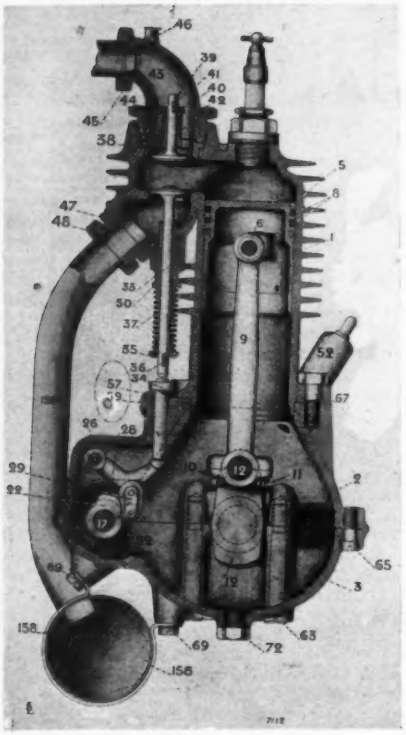
Smooth running, which is impossible with a single-cylinder motor, may be obtained with several, and especially four cylinders, which latter also permit of the speed being varied without shock or jerk. Accordingly, a positive method of transmitting power from the engine shaft to the driving wheel, involving the use of spur and bevel gear, has been adopted, and, as this would not be possible with a single-cylinder motor, there is additional reason for adopting the four cylinders.

As will be seen by the accompanying photograph reproduction, the four vertical cylinders are arranged in line underneath the main horizontal bar of the frame, being kept as low as possible from considerations of stability, and the cylinders are surrounded by the lower member of the frame, which is here made double and of oval-section steel tubes. The hind end of the crank shaft carries a heavy fly-wheel for equalising the motion, and with it is connected an elastic clutch, which transmits the motion to a short shaft carrying a spur wheel that takes into another, fast on a shaft revolving in one of the steel tubes on either side of the hind wheel, and gearing with a bevel wheel fast on the hind axle. The very favourable results that have been obtained with four cylinders in motor-cars afford a further reason for their being selected in the present case.

Moreover, in a single-cylinder motor there is but one spark for two revolutions of the main shaft, whereas with four cylinders there is one for every half revolution, an arrangement which ensures more regular and continuous transmission of the motor's power. Again, there is almost perfect balance of the working parts, impossible with less than four cylinders, that reduces vibration to a minimum, and neutralises the strains on the frame. The efficiency of an explosion motor depends upon the rapidity with which the heat is taken off, and the four-cylinder variety has a surface of more than 50 per cent. greater than that of a



4-CYLINDER MOTOR BICYCLE.



SECTION THROUGH CYLINDER, 4-CYLINDER MOTOR BICYCLE.

single-cylinder motor, a surface which is further increased by the gill form given to the outside of the cylinders.

The new elastic fork, a combination of steel springs and rubber plugs, prevents jerks in the plane of steering, while in no way interfering with the operation of steering itself. The speed may be varied by moving one or both of two levers, one varying the moment of ignition, and the other the quantity of explosive mixture admitted.

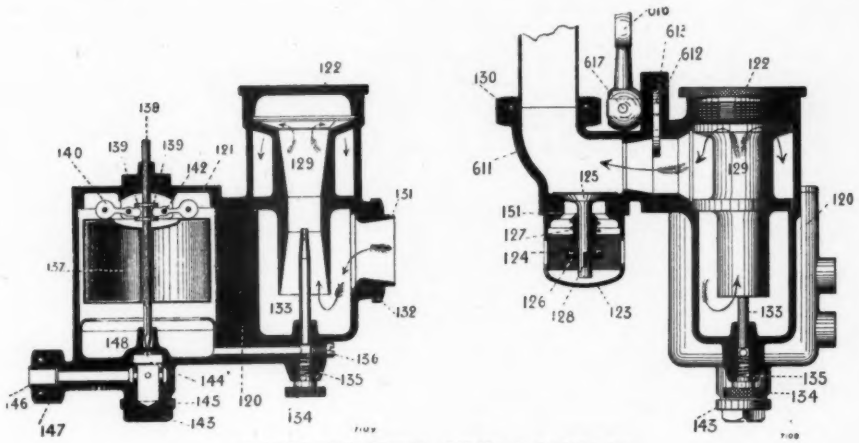
The suction of the piston in the cylinder causes the petrol and air to penetrate simultaneously into the carburettor, which is shown by two vertical sections taken at right angles to one another. The supply of air and spirit is made to vary with the different speeds of the motor, the former by a self-acting valve and the latter by a constant level regulator, while a complete mixing of the gases is ensured by giving them a sudden change of direction, as shown by the arrows. This carburettor consists, it will be seen, mainly of two parts —the regulator and the injection chamber.

The spirit descends from the receiver to the float-chamber, and flows through the filter-plug 143, which has a circular groove corresponding with the inlet tube. This groove communicates by two holes with the interior of the filter-plug, closed at its end by wire-gauze for preventing impurities from passing. In the centre of the cylindrical float is a spindle 138, the point of which closes the spirit supply pipe, and the threaded cover 121, which closes the float chamber, has a hole in its centre to guide the spindle. Under this cover are two armed levers 140, pivotting on pins 142, having at their outer ends counter-weights that bear on the top of the float, while their short inner ends oblige the spindle to descend and close the orifice on the float rising. When, on the contrary, the float descends, the levers act on the spindle so as to again uncover this orifice. The weight of the float and levers is so adjusted that the constant level of the spirit comes a little below the upper part of the injector. The descent of the piston in the cylinder, producing a partial vacuum, causes the spirit to rise in the injector, so that a drop is constantly formed at its hollow apex, while at the same time air, heated by passing over the outside of the cylinders, is drawn in.

The automatic valve, for regulating the air supply, so as to prevent the gas from becoming too rich, is marked 125, a wire gauze in the cover 123 excluding impurities. The opening of this valve, and consequently the volume of air admitted, are proportionate to the speed of the motor, while at the same time the mixture is maintained at its highest degree of explosibility.

For rendering riders independent of charging stations, a magneto is employed, which gives a strong spark and is easily adjusted. The low-tension current generated is transformed, by interruption in the appliance itself, into a high-tension current that passes into the distributor, which directs the current into each of the four cylinders successively, for producing the spark at the moment required.

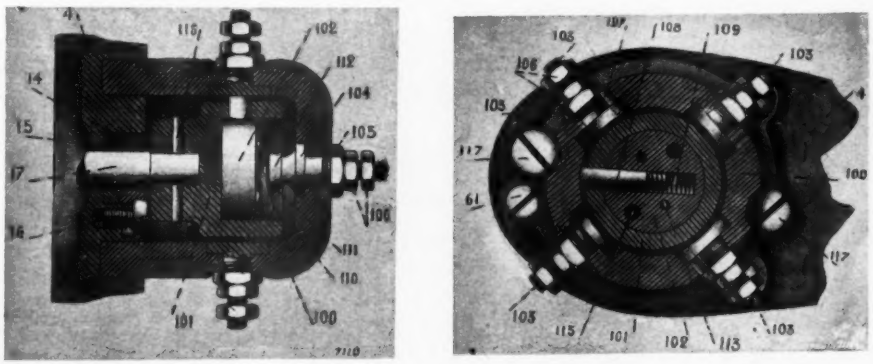
The distributor, shown by two sections at right angles to one another, comprises two distinct parts—the case 100 and the slide-holder 101—which latter consists of a specially shaped insulating bar, rivetted to the end of the cam-shaft 1f, that projects



4-CYLINDER MOTOR BICYCLE. DETAILS OF CARBURETTOR.

from the front of the gear-case 4. In the hollow of the slide-holder a brass disc 102, fastened by two screws 115, carries a spring with carbon contact attached. The slide-holder and disc are drilled together to a certain depth, and in the hole thus made is inserted a carbon slide 108, fitted to a spring 109. In the middle of the distributor body, made of an insulating material and bell-shaped, is fastened a central contact 104, and in a plane perpendicular to the axle are four lateral contacts 103, which are insulated and spaced at angles of 90 degrees. The current passes through the magneto wire attached to the central contact, and then through the carbon contact, the spring, the disc, and the carbon slide. The speed of the distributor is half that of the magneto, and at the moment of sparking the carbon-slide bears against one of the lateral contacts, which are connected with the sparking plugs of their respective cylinders. After two revolutions of the motor, corresponding with one revolution of the cam-shaft, the carbon-slide has reassumed its original position, having produced a spark in each of the four cylinders.

Each motor cylinder is cast separately with its annular gills already referred to, while the valve chambers form part of the



4-CYLINDER MOTOR BICYCLE. DETAILS OF DISTRIBUTOR.

cylinders, and the sparking plugs are fitted to their upper parts, this arrangement preventing loss of gas through defective joints. The pistons, cast of special iron, are provided with packing rings, each being turned a little out of centre, and then a diagonal slot is made in its thinnest part. The outward pressure of the ring against the inside of the cylinders secures perfect tightness, provided the slots be arranged so as to break joint. The piston pins carry the top ends of the connecting rods, the lower ends of which work directly on to the crank. The crank-shaft, which revolves rigidly in five bearings, carries the heavy fly-wheel at one end, and a spur-wheel for transmitting motion to the ignitor and distributor at the other. If the cylinders be numbered 1, 2, 3 and 4 from rear to front, arranging the explosions in the order of 1, 3, 4, 2 gives the most favourable distribution. The case, which collects the oil after it has lubricated the moving parts, is cast of a high-quality iron, in preference to aluminium, which does not afford sufficient rigidity.

Both the admission and exhaust valves are of nickel steel, because it is subject to neither oxydation nor expansion, so that the valves keep tight. Those for admission, which are self-acting, have removable seats, which at the same time serve to guide the valves and support their springs. The exhaust valves are controlled, because their working must synchronise with that of the motor, this control being effected by the cam-shaft, which revolves once for every two revolutions of the crank-shaft.

Although the motor has four cylinders, it certainly is not complicated, while the cylinder parts are interchangeable and easily replaced. When making 1,800 revolutions per minute, the motor develops 3 h.-p. Notwithstanding the many improvements introduced, the new machine is sold for less than £40, which is possible because the parts are finished by automatic machines tended by women, both the one and the other being kept in the highest state of efficiency by fitters and doctors on the spot.

Locomotive and Railway Notes.

By CHAS. S. LAKE.

New Great Western Tank Locomotives.

A NEW class of tank engine has recently been introduced upon the Great Western Railway for working fast passenger traffic on the main line, within, of course, certain limitations of distance. One of these locomotives is illustrated in Fig. 1 by an outline drawing, from which it will be seen that the 4-4-2 wheel arrangement has been adopted, thus bringing into existence one more new type of engine on the Great Western. Locomotives of this type have been employed for many years upon the London, Tilbury and Southend Railway for working a similar class of traffic, but the new Great Western engines have larger general proportions than the others referred to, and there are also important differences in respect of detailed construction between the two designs.

The cylinders, wheels, and motion of the new locomotives are identical with those of Mr. Churchward's "County" class express engines, but the boiler, although of the same pattern, is somewhat smaller, this being compulsory owing to the presence of side tanks. The engines have one distinctive feature, viz., they are fitted with the largest coupled wheels of any tank locomotives running in this, or, so far as the writer is aware, any other country. They are, therefore, specially adaptable for high speed, and, being provided with water pick-up apparatus for use when running in either direction, they may be employed on trains booked to cover considerable distances without stopping. The principal dimensions are as follows :—

Cylinders, 18 in. dia. by 30 in. stroke.
Coupled wheels, 6 ft. 8½ in. dia. on tread.
Bogie wheels, 3 ft. 2 in. dia.
Radial truck wheels, 3 ft. 8 in. dia.
Boiler, dia. of barrel, 4 ft. 5⅛ in. and 5 ft. 0⅛ in.
" length of barrel, 11 ft.
" number of tubes, 289.
" dia. of tubes, 1⅝ in.
" length of tubes, 11 ft. 4 5/16 in.
Heating surface, tubes, 1396·58 sq. ft.
" " fire-box, 121·31 sq.
" " total, 1517·89 sq. ft.
Grate area, 20·35 sq. ft.
Working steam pressure, 195 lb. per sq. in.
Water capacity of tanks (total), 2,000 gallons.
Tractive force, 21·190 lbs.

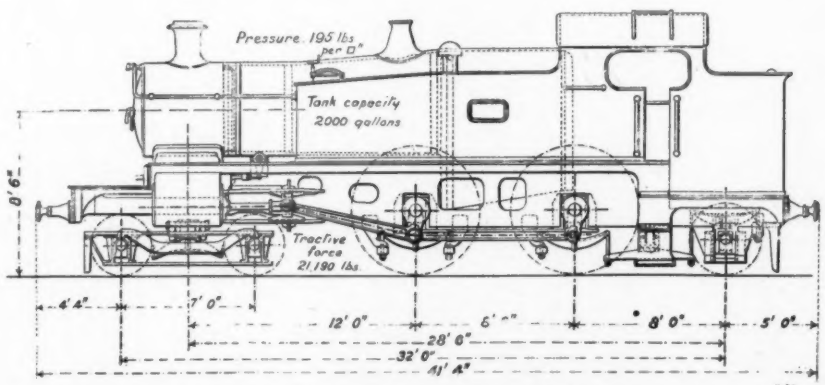


FIG. 1.—NEW TYPE OF PASSENGER TANK ENGINE, GREAT WESTERN RAILWAY.

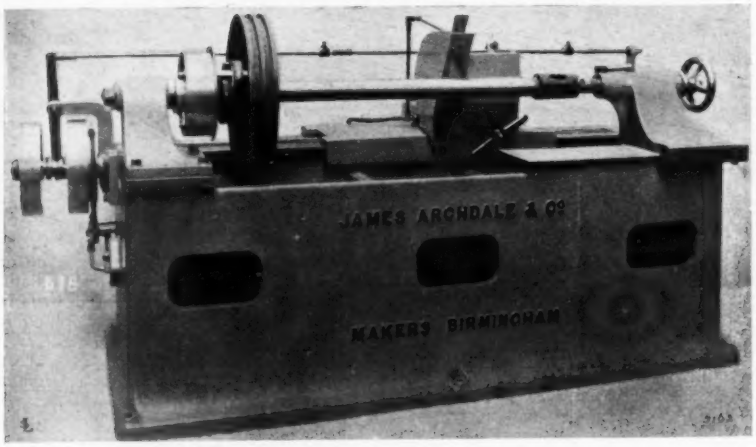


FIG. 2.—PISTON-ROD GRINDING MACHINE, BY MESSRS. JAMES ARCHDALE & CO.

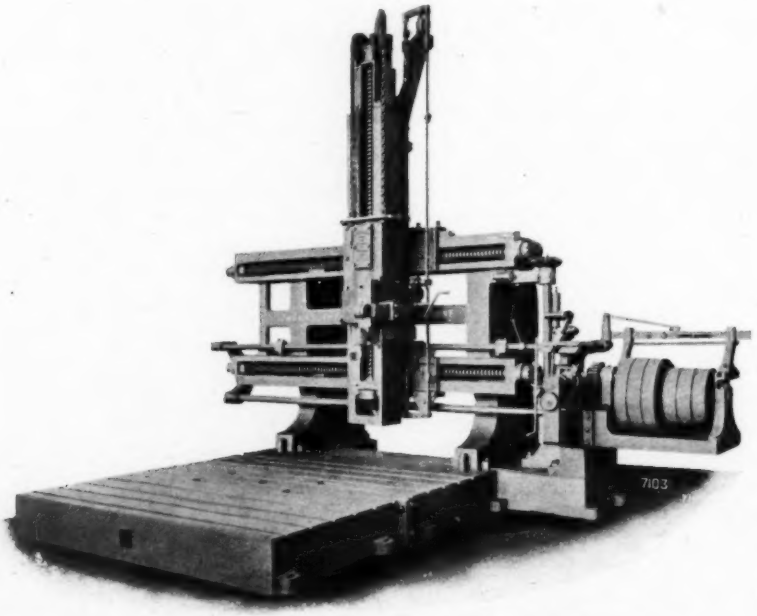


FIG. 3.—VERTICAL AND HORIZONTAL PLANING MACHINE FOR LOCOMOTIVE DETAILS, BY MESSRS. THOMAS SHANKS & CO.

Machine Tools in Railway Workshops.

THE construction and maintenance of the modern locomotive render necessary the use of appliances by means of which building and repair work, in railway and other shops where such operations are carried out, may be performed with accuracy and despatch, involving the rapid handling and manipulation of heavy items in cast-iron, steel and other material, and ability to deal expeditiously with repetition work of al descriptions. Even a casual glance through a few of the railway shops in this country will suffice to show that manufacturers of machine tools have succeeded in bringing their productions to an advanced stage of perfection, both in respect of construction and capability for performing the work for which they have been designed.

The writer proposes to refer from time to time in these notes to workshop plant of the description now under notice, and the accompanying illustrations, with brief descriptions of the tools they represent, will serve as a commencement in this direction.

Fig. 2 shows a piston-rod grinding machine made by Messrs. James Archdale & Co., of Ledsam Street, Birmingham, and supplied by them to many of the leading railway companies. This machine is specially designed for grinding piston and valve rods, &c., and by its use rods of from 4 to 8 ft. in length and 6 ins. in diameter may be accurately and expeditiously dealt with. The emery wheel used for the grinding operation is 12 ins. diameter, and its slide has a transverse movement so arranged that the cut may be put on either from the front or back of the machine. The spindle carrying the grinder is of large diameter; it is hardened and ground true, and runs in conical bearings. The travel of the carriage is adjustable, and is automatically reversed at each end of its stroke. The bed is designed for great rigidity; it is of box section, and a trough, fitted with a strainer, is provided for removing the emery dust, thus permitting of the water being used over again. All the working parts of the machine are protected from grit, and a rotary pump, for use in connection with wet grinding, is fitted. This is a very useful tool, much in favour in locomotive building and repair shops.

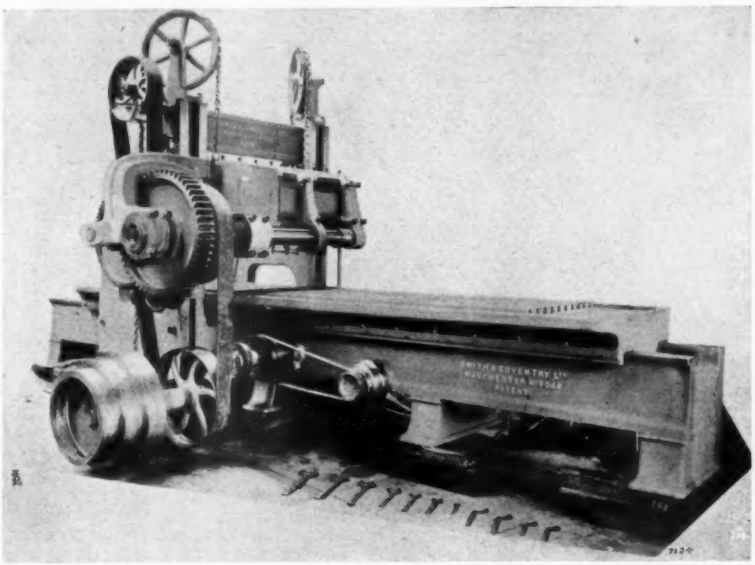


FIG. 4.—IMPROVED HORIZONTAL MILLING MACHINE, BY MESSRS. SMITH AND COVENTRY.

Fig. 3 shows a vertical and horizontal planing machine by Messrs. Thomas Shanks & Co., of Johnstone, for machining locomotive details and other work of moderate size rapidly and without resetting. The front of the machine being quite clear, work can be dealt with which would otherwise require to be done in a very large machine, and as the bottom of the bed is clear of the base plate, work of moderate depth can pass under it, the saddle being made low to overhang and to allow of the tool coming close to the base plate. The vertical bed is fitted with a balanced saddle, serrated in-cutting slide, and two steel serrated bars, one long and one short, with interchangeable steel relief box. Each machine includes a double horizontal slide and uprights in one casting, with a base plate formed of two castings bolted to it, the whole forming a complete structure possessing great rigidity. The driving bracket is strongly made, and has fast and loose pulleys, automatic strap-shifting details, and a cross and open belt to give a quick return of from two and a half to three to one. The planing motion is by two screws, and the slotting motion by a single screw with details for eliminating friction. Both are connected to the driving bracket by bevel gear, the bracket being provided with complete details for self-acting feeds for all motions, including the in-cutting slide. The machine will plane to 7 ft. 6 in. horizontally and 6 ft. vertically. The length of the in-cutting slide is 22 in., and the width 13 in. The base plate is 11 ft. long, 7 ft. 6 in. wide, and 11 in. deep. The extreme height of the machine is 12 ft. 10 in., and the extreme length 15 ft. 6 in.

A machine very largely used in locomotive shops is illustrated in Fig. 4. This is a horizontal milling machine of improved design, made by Messrs. Smith and Coventry, of Manchester. It is specially designed for milling the surfaces of connecting and coupling rods, and other work of a similar class. It is capable of dealing with heavy cutting in steel, producing at the same time highly-finished surfaces. The 3 ft. machine is capable of milling the big ends of two steel connecting rods, each $1\frac{1}{2}$ in. wide, simultaneously, removing $\frac{1}{4}$ in. to $\frac{3}{8}$ in. depth of metal from each, with a feed of $\frac{3}{4}$ in. per minute. The table is driven by screw, and has a variable self-acting traverse in one direction with adjustable knock-off stop. The cross slide is counter-balanced, and is of massive and rigid design, carried on strong uprights. It is raised and lowered by means of screws actuated from the ends through worms and worm-wheels, and moves easily in both directions. The saddle carries the horizontal cutter spindle, and is traversed along the cross slide by screw, thus giving, with the vertical adjustment, complete control over the position of the cutter. It also carries a bracket to support the end of the cutter mandrel. The spindle is of steel, with adjustment for taking up wear; it is driven through powerful gearing so arranged that the position of the cutter does not interfere with the tension of the belt.

High Speed on Railways.

With the commencement of the summer train services on July 1st a further increase in the speed of certain trains on some of the more important railways running out of London was instituted. In some cases the accelerated timings were arranged for by deleting all intermediate stops and running the entire length of the journey without any booked halt *en route*, but in others, such, for instance, as those already performed on the non-stop basis, increased speed alone supplied the means of complying with the new schedules.

A great deal has been written from time to time on the subject of the desirability, from the travelling public's point of view, of high railway speed, and an outstanding feature of such discussions has always been the steadfast, and almost frantic, support given by a certain class of writer whose arguments in favour of high, if not excessive, velocities are conspicuous for the delightful manner in which all considerations, both of a commercial and engineering character, are ignored. Speaking upon this subject of high railway speed, the general manager of one of the largest and most important British railway companies expressed to the writer the opinion that "limited" expresses, run at more than ordinarily high rates of speed, can be made to pay; but on the other hand it is a well-known fact that the majority, if not all, of the locomotive chiefs and others connected with that department deprecate the introduction of such trains, and the grounds of their contention when looked into are, it must be admitted, uncommonly sound ones. At present, at all events, no railway company can afford to build a special class of engine adapted for running at extreme velocities with light trains, and it is difficult to see how traffic is to be encouraged up to the point of making it sufficiently remunerative to warrant the building of such engines.

It is probable that the new timing of the "Sheffield Special" on the Great Central

Railway will go far towards satisfying those who advocate higher speeds on railways. This train after leaving the Metropolitan tracks at Quainton Road has to make an average running of 64·4 miles per hour, and the locomotives used have four wheels coupled of 6 ft. 9 in. diameter. They are among the finest in the country, and are capable of anything achieved by similar engines on other railways, as the writer can testify after considerable footplate experience of them; they were, however, designed not for special traffic of this class, but for all-round work on passenger service, mainly consisting of hauling heavy, well-filled trains at speeds of from fifty to fifty-six miles per hour, and keeping time under varying conditions of weather and other circumstances. These speeds are surely sufficient for the needs of all ordinary passengers to whom ten minutes or so on a journey of three to four hours is of little moment, whilst such an extension of time would more often than not make all the difference in the world to the driver and fireman.

Whatever view one may be inclined to take of this matter, there can hardly be any question but that those who desire to travel at an average rate of over sixty miles per hour should certainly be made to pay something extra for whatever benefits they obtain by so doing.

Twenty-Ton Coal Wagons: Great Northern Railway.

ALTHOUGH the high-capacity bogie mineral wagons now largely used on certain British railways possess many points of superiority over the smaller types of wagons running upon four wheels only, there is no doubt that the latter can, and probably will for some time to come, be profitably employed where the conditions are such that the heavier and more capacious bogie stock is unsuitable, and during the past few years railway companies have been putting into service wagons which may be classed as an intermediate type between the standard ten-ton vehicles and those ranging from thirty to fifty tons capacity. These are adapted for carrying loads of from fifteen to twenty tons of coal, and whilst the four wheels are retained, it has been found possible to adjust the ratio between tare weight and paying load in a favourable manner.

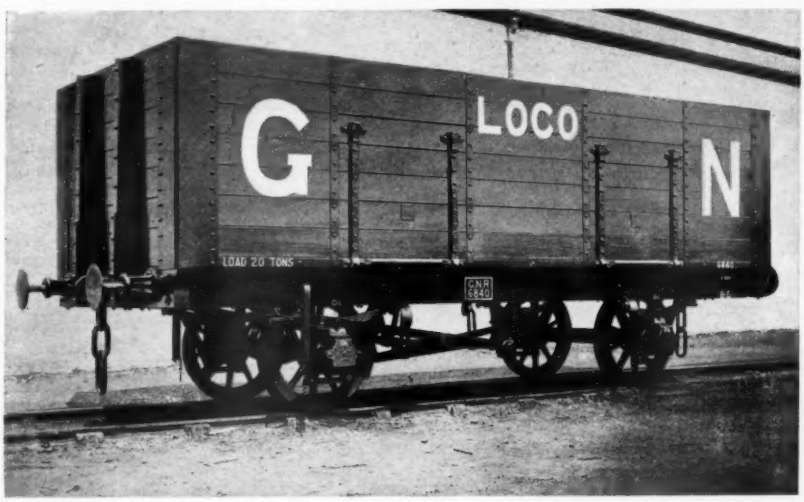


FIG. 5.—20-TON LOCO. COAL WAGON, GREAT NORTHERN RAILWAY.

On the Great Northern a number of such wagons have been introduced for the conveyance of coal used by the locomotive department. They are of the design shown in Fig. 5, and are of twenty tons capacity, the tare weight being only eight tons five cwts. The body of each wagon is built of wood, and has two hinged doors 4 ft. wide

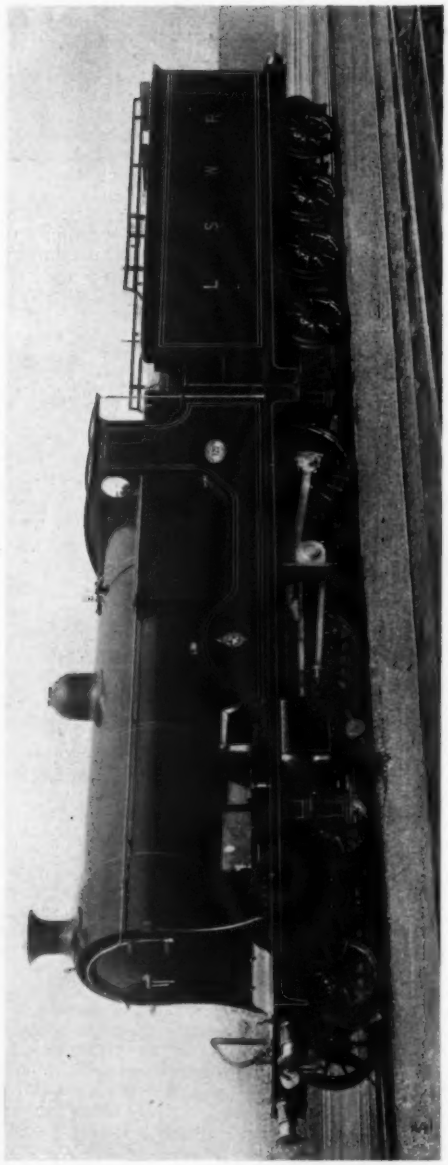


FIG. 6.—REBUILT FOUR-CYLINDER EXPRESS LOCOMOTIVE, LONDON AND SOUTH-WESTERN RAILWAY.

by 2 ft. 11 in. high on each side. The length over buffers is 24 ft. 6 in., and the body measures 20 ft. 6 in. in length by 8 ft. 5 in. wide. The inside dimensions are 21 ft. 1 in. by 8 ft. by 5 ft. $2\frac{1}{8}$ in.; the floor level is 4 ft. $0\frac{1}{2}$ in above rails, whilst the height over all is 9 ft. $2\frac{3}{8}$ in.

The wheels have a diameter on tread of 3 ft. 2 in., and they are spaced with their centres 12 ft. apart; the journals are 10 in. long by 5 in. diameter, and the axle boxes are lubricated with oil. Morton's hand brake is fitted, acting on each of the four wheels.

London and South Western Railway Four-Cylinder Express Locomotive.

REFERENCE was made in the August Notes to the fact that Mr. Dugald Drummond, Chief Mechanical Engineer of the London and South Western Railway, had designed a new class of four-cylinder "simple" express locomotive, with six-coupled wheels and a leading bogie; and it was also stated that his other class of four-cylinder engine, of which several have been in service for some time, were being rebuilt with larger boilers. Through the courtesy of Mr. Drummond the writer is now enabled to refer in greater detail to these engines as altered, and Fig. 6 shows No. 720, the pioneer of the series as now running. The boiler is larger and has a considerably increased area of heating surface, thus enhancing the value of the locomotives for heavy fast work. There is no class of engine which requires such ample power of steam generation on the part of the boiler than does the multi-cylinder simple locomotive, for in this type there is no increase in the range of expansion as a result of employing the extra cylinder or cylinders, whilst it goes without saying that a larger volume of steam is used during every revolution of the wheels, thus causing an increased drain upon the resources of the boiler for rapid steam generation. These South Western engines occupy a distinctive position among British locomotive types in that they are the only ones having the 4-2-2-0 wheel arrangement in the

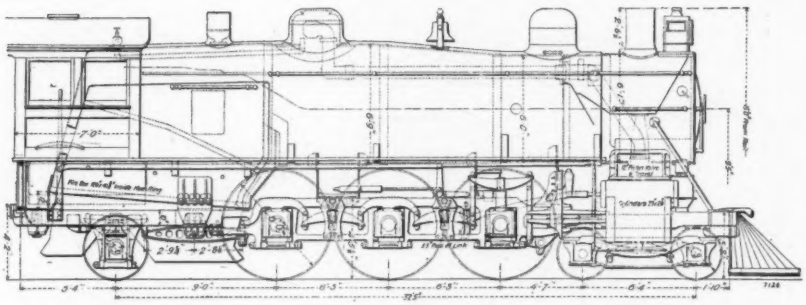


FIG. 7.—EXPRESS PASSENGER LOCOMOTIVE, CHICAGO, MILWAUKEE, AND ST. PAUL RAILWAY.

country, and in addition to this they are, with the exception of a single example on the Great Northern, and another on the Glasgow and South-Western Railway, the only four-cylinder "simple" engines in use on a British railway. The following comparative dimensions will make clear the extent of the alterations effected by the rebuilding process:—

As originally built.	As now running.
Boiler dia., 4 ft. 4 in.	5 ft.
Heating surface (tubes), 1,307 sq. ft.	1,392 sq. ft.
" " (firebox), 142 "	175 "
" " (water-tubes), 215 "	195 "
" " (total), 1,664 "	1,762 "

The grate area remains as before, viz., 27·5 sq. ft.

Heavy Express Passenger Locomotives for the Chicago, Milwaukee, and St. Paul Railway.

SOME exceptionally large and powerful locomotives have recently been placed in service on the above railway for hauling heavy passenger trains. They are of the "Pacific" or 4-6-2 type, and were built at the company's shops at West Milwaukee from the designs of Mr. A. E. Manchester, Superintendent of Motive Power. The engines are fitted with two simple expansion cylinders outside the frames, 23 in. diameter by 26 in. stroke, driving the intermediate pair of coupled wheels. With 200 lbs. of boiler pressure there is a tractive effort of 32·475 lbs., and the ratio of tractive weight to tractive effort is 4·37. The three-coupled axles are placed in advance of the firebox, and the trailing end of the locomotive is carried upon a two-wheeled truck as shown in Fig. 7. Ordinary link motion pattern valve-gear is employed for actuating the valves, which are of the piston type, 12 in. in diameter with 6 in. travel, working above the cylinders. The boiler is of the extended wagon top or "coned" pattern, with the steam dome located on the ring next the firebox, and a cylindrical dome shaped sand box on the front ring. These locomotives, which are among the heaviest and most recent passenger engines in the United States, have dimensions as follows: Cylinders, 23 in. by 26 in.; coupled wheels, 6 ft. in diameter; rigid wheelbase, 12 ft. 6 in.; total wheelbase (engine) 32 ft. 5 in.; height of boiler axis above rails, 9 ft. 5 in.; diameter of boiler barrel at front end, 6 ft.; number of tubes, 363, 2 in. diameter; length over tube plates, 16 ft. 6 in.; heating surface, tubes, 3,136 sq. ft.; firebox, 245·6 sq. ft.; total, 3,381·6 sq. ft.; grate area, 35·84 sq. ft.; steam pressure, 200 lbs.; weight on coupled wheels, 63 tons 8 cwts.; total weight (engine) 97 tons 7 cwts.

Internal Combustion Engines.*

By DUGALD CLERK, M.Inst.C.E.

An internal combustion engine is a heat engine in which the working fluid is atmospheric air, and the fuel is an inflammable gas or vapour. It differs from a hot air or steam engine in one important point, that is, the heat to supply the motive power is given directly to the working fluid by combustion within the motor cylinder.

It has long been recognised that an engine operating upon what is called the Carnot cycle gives the highest conversion of heat possible between the available temperature limits. The diagram, Fig. 1, shows what occurs in an engine operating in accordance therewith. In order to be explicit, I have calculated out this diagram for an engine operating with a maximum pressure of 500 lbs. per square inch absolute, using pure air as the working fluid.

With an air engine operating in this manner the proportion of heat converted into work is very easily calculated. All the heat is added at the upper temperature, and all the heat discharged at the lower temperature. It can be readily shown that the efficiency is

$$\frac{T - T^1}{T}$$

T being the upper temperature, and T^1 the lower temperature. Such an engine converts all heat into work which can be converted. The second law of thermodynamics, on which the reasoning from the Carnot cycle is based, proves that only a certain proportion of the total heat given to any working fluid can be converted into work, and that proportion depends upon the difference between the higher and lower temperatures. Under the diagram, Fig. 1, I have marked the principal data, including the higher and lower temperatures, the maximum pressure, and the mean pressure. Also the volume swept by the piston, taking the volume swept for adiabatic compression as unity. From these figures you will see that although the efficiency is the maximum possible within the temperature limits, the performance, that is, the actual amount of work obtained from the engine for a given size of cylinder, is exceedingly low.

Although the maximum pressure is 500 lbs. per sq. in., the mean available pressure is only 6 lbs. per sq. in. for the particular case shown. The efficiency is high, ·64, but obviously an air engine following the Carnot cycle would be useless for all practical purposes, as the mean pressure is so low in proportion to maximum pressure.

In a recent discussion by Professor Callender, he calls the Carnot cycle a constant temperature cycle. At Fig. 2, there is shown a diagram having a similar maximum pressure. This diagram represents that which would be given by an air engine following closely all the conditions of the best known modern types of internal combustion engine, viz., the Otto, or four stroke cycle. In this engine, there is compression of air from maximum to minimum volume without gain or loss of heat; addition of heat at minimum volume, rising from temperature of compression to maximum temperature; expansion without gain or loss of heat to maximum volume; and discharge of heat at maximum volume to original temperature. For the purpose of reasoning clearly, I assume that all heat additions and abstractions are made at constant volume in any manner you may conceive possible. It is better to think of the same mass of air always in use, alternately heated and cooled at constant volume, and alternately compressed and expanded adiabatically. I should say that in both adiabatic compression and expansion, I have assumed the ratio between specific heat at constant volume and constant pressure to be 1·408, so that the equation of each curve is $PV^{1.408} = \text{constant}$. I also assume the specific heat of air to be constant throughout the whole temperature range, and the addition and abstraction of heat to be made without chemical complications.

Under this diagram I have marked the leading particulars, including maximum and minimum temperatures, maximum and mean available pressures.

Here you will observe that with the same maximum pressure as in the Carnot cycle, and a very usual maximum temperature (1,700°C.), the mean available pressure is 105 lbs. per square inch, and the efficiency

* Abstract of a lecture delivered before the Society of Arts.

is ·48. Here, the efficiency, it is true is lower, but the available pressure bears a reasonable proportion to the maximum pressure, and the cycle is a thoroughly practical one.

If one considers this diagram carefully it will become evident that as both compression and expansion lines are adiabatic, the proportion of heat converted into work of that given to the engine is correctly shown by the temperature rise on what I may call the heat addition line, as compared with the temperature fall on the heat abstraction line; that is, in this case the efficiency is also

$$\frac{T - T^1}{T},$$

in this case, however, T being maximum temperature of heat addition, and T^1 the maximum temperature of heat discharge.

From the formula

$$PV^{1\cdot408} = \text{const.}$$

the value of the temperature at both ends of the diagram can be readily calculated for different maximum temperatures; and if you try various maximum temperatures you will at once find that on this particular cycle of operations the efficiency is the same for all maximum temperatures above the temperature of adiabatic compression—that is,

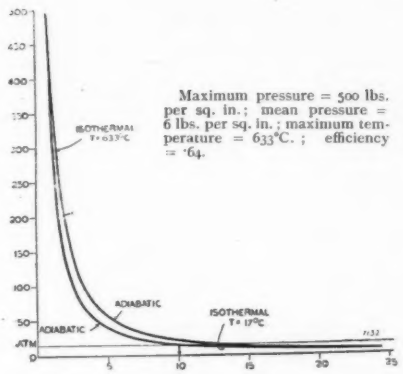
$$E = 1 - \frac{T^1}{T} \text{ or } 1 - \frac{t}{tc} \; ;$$

that is, the efficiency can be expressed in terms of the temperature before and after compression, and is independent of the increase of temperature above the temperature of compression. From this it follows that the efficiency can be expressed in terms of the volume before and after compression; and this worked out gives the efficiency formula as—

$$E = 1 - \left(\frac{1}{r}\right)^{\cdot408}.$$

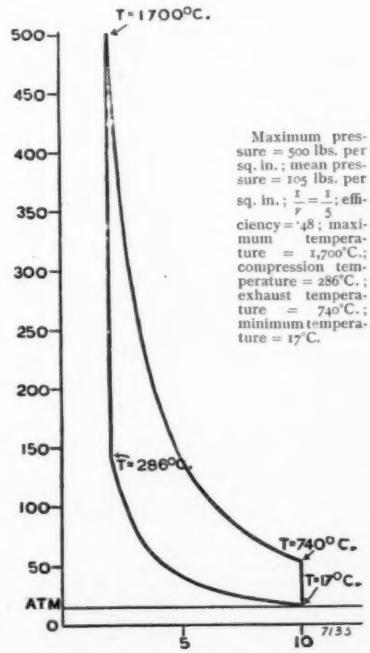
In this particular case, $\frac{1}{r}$ is equal to $\frac{1}{5}$, and the efficiency would be ·48, that is, if 100 units of heat be given to an engine operating on this cycle, with these proportions, 48 of these heat units would be converted into mechanical work.

At Fig. 3 I have shown another diagram, which resembles the last two diagrams in one feature. The maximum pressure is the same. In this case, however, adiabatic compression has been carried to the maximum pressure, and heat is added, not at constant volume, but at constant pressure.



Maximum pressure = 500 lbs. per sq. in.; mean pressure = 6 lbs. per sq. in.; maximum temperature = 633°C.; efficiency = ·64.

FIG. 1.—DIAGRAM FROM AIR ENGINE OPERATING ON CARNOT CYCLE.



Maximum pressure = 500 lbs. per sq. in.; mean pressure = 105 lbs. per sq. in.; $\frac{1}{r} = \frac{1}{5}$; efficiency = ·48; maximum temperature = 1,700°C.; compression temperature = 286°C.; exhaust temperature = 740°C.; minimum temperature = 17°C.

FIG. 2.—DIAGRAM FROM AIR ENGINE OPERATING ON OTTO CYCLE.

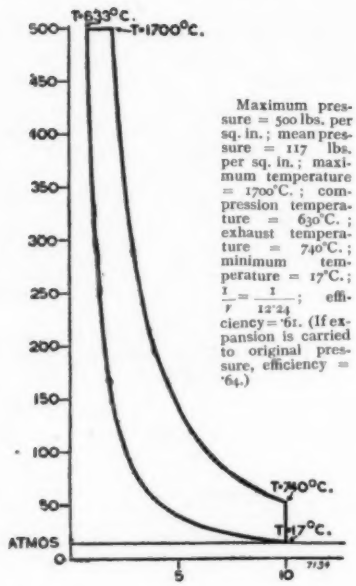


FIG. 3.—DIAGRAM FROM AIR ENGINE, WITH HEAT ADDED AT CONSTANT PRESSURE AND HEAT DISCHARGED AT CONSTANT VOLUME.

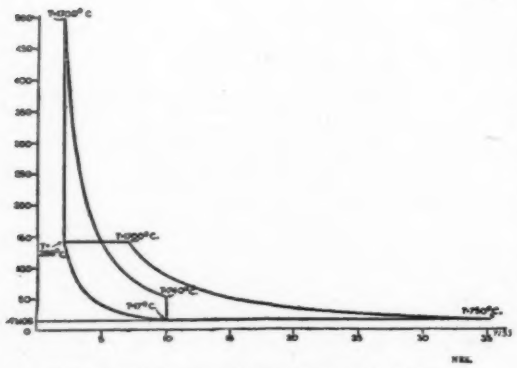


FIG. 4.—DIAGRAMS FROM CONSTANT VOLUME AND CONSTANT PRESSURE CYCLE AIR ENGINES.

	Constant Volume.	Constant pressure.
Maximum temperature ...	1,700°C.	1,700° C.
„ pressure	500 lbs. per sq. in.	141·1 lbs. per. sq. in.
Mean pressure	105 lbs. „ „	37 lbs. „ „
Efficiency	·48	·48

In this diagram the engine performs the following operations:—Compression of initial volume of air to desired compression pressure, without gain or loss of heat, addition of heat to maximum temperature at the pressure of compression during expansion for a certain period; expansion without gain or loss of heat to initial volume, and discharge of heat at initial volume during fall of temperature to initial value.

Here a very high mean pressure is obtained, and the efficiency is but little lower than that given by the Carnot cycle. If the expansion in this case be carried far enough to cause the pressure to fall to the initial value, then the efficiency is given by the same formula as the constant volume cycle. It is ·64. The mean pressure, however, is much lower: it is only 56 lbs.; so that although there is a greater heat conversion, the engine is much heavier for the power.

This cycle may be called the constant pressure cycle, because in a perfect example heat is added and discharged at constant pressure.

Fig. 4 shows a constant volume cycle, such as is seen at Fig. 2, combined with a constant pressure cycle arranged for the same compression. This diagram clearly shows the relationship between the two cycles for the same compression and the same maximum temperature. In this case it will be observed that a greater expansion is necessary to obtain the same efficiency in the constant pressure case, and that in this constant pressure cycle the maximum pressure is lower. In this constant pressure cycle also the efficiency is the same for all heat additions above the temperature of compression, the condition of maximum efficiency for these circumstances being expansion to atmosphere. It is interesting to note that here we have the same efficiency formula for the constant volume and constant pressure cycles, the efficiency depending on the compression ratio only. The fact that these efficiencies were the same was first recognised by me in 1882, and for many years other engineers, notably M. Witz, of Lille, have also recognised this interesting fact.

Professor Callender has pointed out, however, that even in the Carnot cycle the efficiency is determined by the adiabatic compression line, and that it also has the same value for a given compression as is found for either constant volume or constant pressure cycles.

Fig. 5 gives a combined diagram, in which Carnot, constant volume and constant pressure cycles are shown, the feature common to the whole three, however, being that the maximum pressure is the same. In this case the Carnot cycle and constant pressure cycle have the same efficiency; but the constant volume cycle has a less efficiency. These diagrams, with the details marked under them, will prove useful to engineers designing gas engines, as showing pressures which would be given by ideal air engines corresponding closely to the different types; but the most interesting and important, from the manufacturing engineer's point of view, is, of course, that dealing with the efficiency of the constant volume cycle. This is the cycle which is followed in the majority of cases now. Only one constant pressure engine appears to be upon the market at present, viz., the Diesel oil engine.

Fig. 6 is a diagram which illustrates the efficiencies of constant volume engines at different compressions. A range of three diagrams is shown, in which the heat additions are all equal to one another, and equal to the heat addition illustrated in Fig. 2. This diagram at once shows clearly to the eye the fact that, as compression increases, greater conversion of heat into work results. This can be calculated from the formula

$$E = 1 - \left(\frac{1}{r}\right)^{\cdot 408},$$

and I have made a calculation for the following values of $\frac{1}{r}$:—

TABLE I.

$\frac{1}{r}$	E
$\frac{1}{2}$	·246
$\frac{1}{3}$	·36
$\frac{1}{4}$	·43
$\frac{1}{5}$	·48
$\frac{1}{7}$	·55
$\frac{1}{10}$	·61
$\frac{1}{20}$	·70
$\frac{1}{100}$	·85

From these calculations it becomes at once evident that there is a very large thermodynamic gain, due entirely to increased compression or diminished compression space volume. The efficiencies range from compression space equal to $\frac{1}{2}$, giving an efficiency of ·246, up to compression space equal to $\frac{1}{100}$, giving an efficiency of ·85 These, of course, are efficiencies which could only be obtained in an ideal engine, assumed to exist without heat losses of any kind, working with air

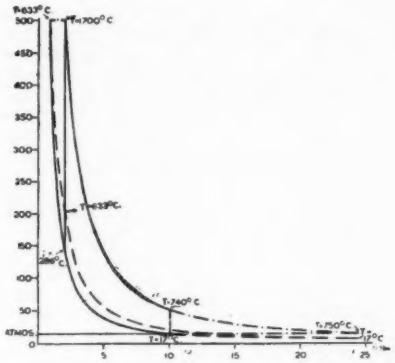


FIG. 5.—DIAGRAM FROM CARNOT, CONSTANT VOLUME, AND CONSTANT PRESSURE CYCLE AIR ENGINES.

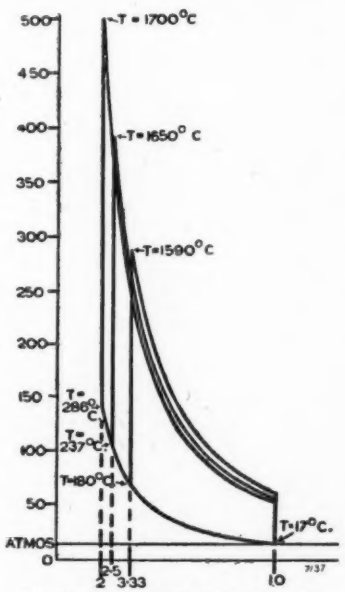


FIG. 6.—DIAGRAMS FROM OTTO CYCLE AIR ENGINES AT DIFFERENT COMPRESSIONS.

	Maximum pressure per sq. in.	Mean pressure per sq. in.	Efficiency.
$\frac{1}{r} = \frac{1}{5}$	500 lbs.	105 lbs	·48
$\frac{1}{r} = \frac{1}{4}$	391 lbs.	101 lbs.	·43
$\frac{1}{r} = \frac{1}{3}$	287 lbs.	97 lbs.	·36

having a constant specific heat, and so operated that no valve losses or throttle losses were incurred. I need not tell you that no actual engines give efficiencies so high as these for any given compressions.

The increase of thermodynamic efficiency due to compression is caused by something more than the increased expansion which is obtained. At first sight one would think that if a great enough expansion could be obtained with an explosion, say starting at atmospheric pressure, the same results should be given as we get with a corresponding compression and equivalent expansion. This, however, is not the fact. Mere expansion does not give the efficiencies obtained by adiabatic compression and then expansion. This appears to be due to the fact that by compressing a gas without loss or gain of heat, either at constant volume or constant pressure, the whole of the heat absorbed during the subsequent ignition is utilised for the purpose of doing the available work of expansion. This may be clearly seen by considering the case of an engine compressing not on an adiabatic line, but an isothermal line. In this case, in addition to the heat added for doing the available work of expansion, there is a large proportion of heat added for doing that part of it which is unavailable. The reasons why compression, then, produces such great economies, are: (1) it allows of large range of expansion, and (2) it allows of the heat which is added being available for producing the work of the actual indicator diagram. It is somewhat difficult to grasp the abstract reason for the increase of efficiency due to compression; it will, however, from the above considerations, be clearly seen that adiabatic compression forms the basis of all perfect or approximately perfect heat engines. In actual practice, of course, there are other advantages than those flowing from increased efficiency. Compression enables high pressures to be generated within the cylinders, and so reduces the bulk of the engine. It further diminishes the proportional heat losses, and so tends to economy in the practical engine.

Before considering the question of actual efficiencies in engines, it is desirable to understand to some extent what goes on in a gaseous explosion.

So far, most of the work which has been done on gaseous explosions with a view of determining the maximum temperature and cooling curve for different mixtures, have been made with coal gas and air mixtures. Little is known of the cooling curve of petrol, alcohol, and producer gas explosions, except from the behaviour of such gaseous mixtures in the engines.

Table II., however, shows the difference which may be expected from these explosions, so far as mechanical contraction is concerned. One feature, however, stands out clearly in connection with all these gaseous explosions. That feature, is, the apparent suppression of part of the heat of the gas or vapour present at the maximum temperature of the explosion; that is, if the maximum temperature of the explosion be calculated, and it be assumed that the specific heats of the products are constant, then it will be found that the heat evolved by the temperature rise is not equal to that of the gas present. This fact has led to a great deal of discussion among engineers, chemists, and physicists. Some, including many French experimenters, say that the specific heat of air and other gases changes largely at high temperatures, and that the whole heat is evolved at a maximum temperature, but specific heat varies. Others say that the explosion experiments cannot prove this, and that although maximum temperature is obtained, combustion is not completed at that temperature, but goes on for some time after maximum temperature. Others, again, say that dissociation of carbonic acid and water intervenes, and prevents further evolution of heat till temperature falls.

In discussing the application of the theory of compression to the actual efficiencies of internal combustion motors, it is desirable so to arrange matters as to avoid the necessity for accepting any particular theory. In these lectures I propose to do this.

It is desirable, however, always to bear in mind that although for simplicity's sake we discuss internal combustion engine problems as if we had to do with an air engine pure and simple, yet in considering the actual conditions of practically operating engines, the problem is very much more complex. The amount of heat not accounted for by the temperature rise in gaseous explosions, assuming constant specific heat, varies from 30 to about 50 per cent., depending upon the strength of the explosive mixture. If the mixture be approaching the maximum flame temperature, then a large proportion of heat remains unaccounted for. On the other hand, if the mixture be approaching the point of missing firing by over dilution, then heat unaccounted for is equally great. The greatest proportion accounted for is found with intermediate mixtures, such as mixtures of coal gas and air ranging from 1 in 10 to

1 in 12. These are the mixtures which are most economically used in coal gas engines. To understand the conditions of economy, however, it is well to simplify the problem as much as possible. The diagrams reproduced above are the diagrams which a pure air engine would produce, if the specific heat of air were constant at maximum temperature, and if no heat losses whatever were incurred by the contact of the flame with the cylinder; and, further, if no valve losses were incurred, due to throttling during admission, or back pressure during exhaust. These matters I propose to deal with in the next lecture; but meantime we shall confine ourselves to the simplified problem, assuming certain heat losses.

Taking, for example, the constant volume engine, of which the diagram is shown at Fig. 2, this engine, without heat or other losses, would convert 48 out of every 100 heat-units given to it into indicated work. Assume now one simple case of heat loss, that is, heat loss during the expansion stroke only, and assume a phenomenon similar to the actual case in the gas engine cylinder, that is, assume the expansion line to be apparently adiabatic, although in reality heat is flowing away to such an extent that an equal quantity requires to be added during expansion to that which is added at the beginning of the stroke. In this case, it is evident that the calculation for the actual efficiency of the engine is a very simple one. Instead of adding 100 heat-units, 200 have been added, and from these 200, only the work shown upon the diagram has been given. The practical efficiency of this engine would therefore be given by multiplying the ideal efficiency by ·5, that is, half of the idea efficiency would give the practical efficiency.

If the expansion line be above the adiabatic, the problem is by no means so simple, because here, even without heat loss, the efficiency of the expansion is greatly reduced.

In the James Forest Lecture, which I had the honour of delivering to the Institution of Civil Engineers last year, I calculated a number of cases of this kind, and showed that the efficiency suffers considerable reduction by the addition of heat in the expanding line, to keep up an expansion above the adiabatic. In a case of this kind—a case which indeed occurs in practice in large gas engines—it is necessary to calculate the efficiency on the assumption of expansion above the adiabatic, in order to find the real efficiency of the engine which is under examination.

The other engine cycle, *i.e.*, the constant pressure cycle, is one which is also subject to heat loss, but as a considerable part of the work is done during increasing temperature, the heat loss per stroke is somewhat less than in the constant volume cycle, and accordingly some advantage results.

Much has yet to be done, before all the actions going on in the cylinder of the internal combustion motor can be fully understood; and if we hold clearly in our minds the efficiencies possible with engines suffering no heat losses, subject to no complications as to chemical action or change of specific heat, we shall hold a key which will guide us through many complexities, and will supply clear indications of the line of advance.

TABLE II.

RELATIVE VOLUMES OF COMBUSTIBLE MIXTURES WITH OXYGEN AND PRODUCTS OF COMBUSTION.

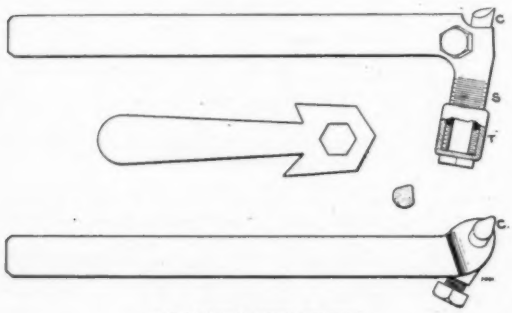
2 vols.	Ethylene	C_2H_4	8 vols. + 6 vols.	O	give	8 vols. 4 vols.	CO_2 +	4 vols. H_2O
2 vols.	Butylene	C_4H_8	14 vols. + 12 vols.	O	„	16 vols. 8 vols.	CO_2 +	8 vols. H_2O
2 vols.	Pentane	C_5H_{10}	17 vols. + 15 vols.	O	„	20 vols. 10 vols.	CO_2 +	10 vols. H_2O
2 vols.	Pentane	C_5H_{12}	18 vols. + 16 vols.	O	„	20 vols. 10 vols.	CO_2 +	10 vols. H_2O
2 vols.	Heptane	C_7H_{16}	24 vols. + 22 vols.	O	„	30 vols. 14 vols.	CO_2 +	16 vols. H_2O
2 vols.	Octane	C_8H_{18}	27 vols. + 25 vols.	O	„	34 vols. 16 vols.	CO_2 +	18 vols. H_2O
2 vols.	Alcohol	C_2H_6O	8 vols. + 6 vols.	O	„	10 vols. 4 vols.	CO_2 +	6 vols. H_2O
2 vols.	Acetylene	C_2H_2	7 vols. + 5 vols.	O	„	6 vols. 4 vols.	CO_2 +	2 vols. H_2O

To advance quickly, it is necessary to understand fully, and many experiments yet remain to be made to enable us to understand the peculiarities of the numerous different gaseous and vapour explosions now utilised in these engines. Experiments have still to be made upon the specific heat of the products of combustion at high temperatures, the laws of cooling of the flames within the cylinders, the laws of combustion, proceeding at the enormous rates experienced in these engines. Especially urgent is the requirement for explosion and cooling curves for coal gas, petrol, alcohol, producer gas, and blast furnace gas explosions. Some of these matters, however, I propose to deal with in considering the indicator diagram in my next lecture.

New Lathe Tool Holder for High Speed Steels.

TO THE EDITOR, *Engineering Review.*

THE difficulty of forging and grinding lathe cutting tools from heavy square stock has led to the devising and patenting of large numbers of holders, in which the cutter is a small section of steel held at a certain suitable angle. None of these have come into general use as they have all had *defects* which counter-balanced their *good points*. The introduction of the new and costly high-speed steels led me to think the matter out, and the result has been the construction of the tool of which particulars are now given. The tool follows the lines of the one manufactured by Messrs. Smith and Coventry, but with an important improvement which entirely obviates all risk of *slipping through downward thrust*. In the drawings (Fig. 1) is a



A NEW LATHE TOOL HOLDER.

side view, and (Fig. 2) a top view of a right hand holder which, with a left hand one with cutter raked to the left, will do all plain turning and surfacing. This holder is suitable for a 6 or 7 in. lathe, and the stock is a piece of $\frac{3}{4}$ in. square mild steel bent over at the end and forged in a die to the shape of the socket as shown. The cutter C is a piece of $\frac{3}{8}$ in. round self-hardening steel, and the hole through socket for same is drilled with a clearance angle, front and side of 10 degrees. The bottom part of the socket is turned concentric with the hole and screwed externally. A thimble T is threaded internally to fit over this socket, and the closed end forms a seat to take the thrust of the cutter. This thimble absolutely ensures the cutter from downward slip, and at the same time enables the height of the cutter (a most important point) to be adjusted with the greatest nicety. The cutter is finally secured by the hob headed side screw as shown at side. The cutters may be round in section and ground to the proper theoretical angle on a very small diameter emery wheel with curved edge, as explained in "Smith's Cutting Tools," p. 159 (Manuals of Technology). I prefer myself to grind off two sides of the round cutter so as to give the angular cutting edges with rounded point as shown in section (Fig. 4). It should be noted that I give a greater face and side clearance to the cutter than is needed, but this excess enables the cutter to be touched up a little on the sides as well as the top in the grinding, and this is a great advantage. The bottom of the thimble is shaped to a hexagon the same size as the head of the side set screw, and a convenient spanner to fit both (Fig. 3) may be stamped from $\frac{1}{8}$ in. thick sheet steel with gauges on either side of the proper angle for grinding the cutters for wrought or cast-iron. No turner having once given this tool a fair trial would ever go to the trouble of forging, shaping and grinding his cutting edges out of the solid and expensive square stock, that is, for all plain turning and surfaceing.

To sum up, the great advantages of this holder are as follows; (1) The thrust of the cut being in the direction of axis of cutter enables small sections of costly steel to be used with the greatest economy. (2) There is very little overhang. (3) The height and position of cutting edges can be adjusted with the greatest facility. (4) There is no risk of the cutting slipping under heavy strain. (5) There is no forging about the cutters which are simply cut off and ground to the proper angle. (6) In resharpening, the surface to be ground is reduced to the minimum. Finally the saving in time, forging, shaping, and cost of solid steel, would soon pay for the holder many times over.

JAMES MUSGROVE,

Victoria, Australia.

Electrical Notes.

By ANDREW STEWART, A.M.I.E.E.

The Ward Leonard Electric Railway System in Switzerland.*

This system of electric traction, which consists in supplying the locomotive with high pressure alternating current by means of an overhead or side trolley, and transforming it down, then converting it to direct current by means of a motor generator carried on the locomotive, the direct current being supplied to the motors, has been in use for some time on several Swiss lines, and recent tests made by the Oerlikon Co. seem to show that, notwithstanding the number of transformations, this system has some claims to attention on the score of efficiency. The following tests were made on a 400 h.-p. locomotive hauling a freight train, the locomotive weighing 45 tons and the train 217 tons. The acceleration test showed that a speed of 18 miles per hour was reached 75 seconds after starting on a level road. With the same train on a grade of 0·8 in 100, 310 kilowatts were supplied through the trolley wire, and the work done at the periphery of the driving wheels was equivalent to 216 kilowatts, giving an efficiency of 70 per cent. The trolley wire pressure was 15,000 volts. The efficiency of the various parts of the apparatus is given as follows:—Motors, gears, and connecting rods, 86 per cent.; motor generator, 85 per cent.; locomotive step down transformer, 98·5 per cent.; the exciter and air pump used 2 per cent of the energy, while the line loss was ½ per cent., which gives an efficiency from power house to locomotive wheels of 69½ per cent.† The watt hours per ton mile were 68·2 on the gradient already mentioned, and 23·7 on the level. Although compressed air was fitted for the brakes, the higher efficiency and smooth braking obtained by reversing the motors led to this being almost always used. It is claimed that, as the speed can be varied over a wide range without rheostatic losses by means of the Ward Leonard system, it is superior to simple single-phase systems on the score of efficiency.

* *Electrical World and Engineer*, July 8th.

† Further data on the efficiency of electric locomotives and trains is given in THE ENGINEERING REVIEW, vol. xii., pp. 871—875.

Large Gas Engines in Electric Power Plants in German Iron-works.‡

SUCH engines using blast furnace and coke oven gases have become very common during the last few years, and our contemporary gives illustrations and details of some notable installations. A new tandem double-acting gas engine of 1,200 h.-p. direct connected to a direct-current generator, the combination running at 100 revolutions per minute, has been installed at the Dillingen Iron Works, Dillingen-on-Saar. This engine has a single crank, there being two cylinders $35\frac{7}{16}$ ins. dia. × $43\frac{5}{16}$ ins. stroke. Fig. 1 shows the general arrangement. An engine has been installed in the generating station of the Halberger Iron Works, which differs in several respects from the foregoing, it is a two cylinder, two crank engine giving 650 h.-p. at 150 revolutions per minute. Each cylinder has a diameter of $25\frac{15}{16}$ ins. × $31\frac{1}{2}$ ins. stroke. The salient features of these engines are as follows:—There is, in the case of the single cylinder engine, an explosion every revolution, and in the case of the tandem, or two crank engines, an explosion every stroke, so that the crank effort leaves little to be desired. In the case of the tandem engine, the compression stroke is used to cushion the moving parts as in a single acting steam engine. The two crank design is, of course, more accessible and can be run if necessary as a single crank engine, while this is difficult, though possible, with the tandem design. The valve gear is arranged for an unvarying mixture of gas and air, the governing being effected by throttling the explosive mixture. The engine may be rapidly altered to use any gas, so that it may be changed over at once from coke oven to blast furnace gas, or any other convenient gas. The cylinder and water jacket are cast in one piece, and arranged that some of the stresses on the cylinder walls are taken by the jacket; the water cooling space is large, and care has

‡ *Electrical Review*. New York, July 1st, 1905.

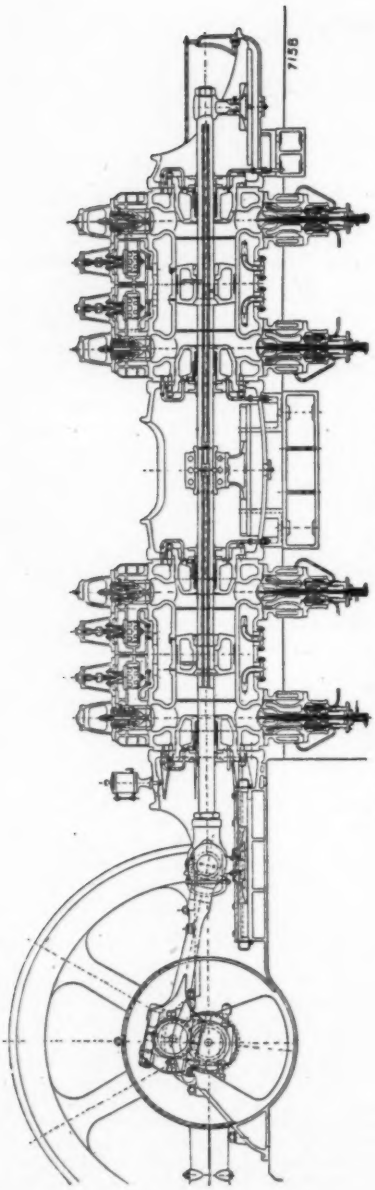


FIG. 1.—700 HORSE-POWER, DOUBLE-ACTING, TANDEM GAS ENGINE.

been taken to secure accessibility for cleaning and inspection. Warping is said to be impossible, as all the strains are evenly divided and take place parallel to the axis of the cylinder. The cylinder covers, back and front, are interchangeable; the cross head guide is open at the top. The piston is of cast iron in one piece, and fitted with cast iron rings. The piston rod, as will be seen from the illustration, is supported at both ends of the cylinder, and the piston and rod are water cooled, the water being admitted through a hole drilled the whole length of the piston rod, a method which has been found very effective. The stuffing box glands are also provided with water cooling, as are most parts subjected to high temperature, the water-cooled glands have been found to wear very little. The packings are metallic and free to move radially. Magneto ignition is provided, and the instant of firing can be adjusted separately for each cylinder. Lubrication has been carefully considered, and the principal working parts are supplied with oil under pressure by a pump driven by the engine. Compressed air is used for starting, and an electrically driven barring gear is fitted to adjust the engine to the starting point, and for valve setting.

Electric Power Plant at Harland and Wolff's Shipyard.§

In the recent reorganisation of the driving arrangements at this yard, a new electric power station was found necessary. The power-house is 469 ft. long by 68 ft. wide, and, as it is built on made ground, extensive piling has been necessary, the walls are carried on 1,000 piles 40 ft. long, on the top of which are wood beams 10 × 9 in., concrete being placed on and around these. The engine, generator, and 180 ft. chimney foundations are carried on piles 12 in. square and 40 ft. long. on the engine foundation piles; 11 × 3 in. channel irons are placed to distribute the weight evenly over the piles, all the latter being of pitch pine. The boiler-room contains five single-ended marine boilers 14 ft. long by 10 ft. 6 in. diam., working at a pressure of 200 lbs. per sq. in. the heating surface of each being 2,225 sq. ft. The gases pass around and under each boiler before reaching the flues. The steam pipe is a 10 in. wrought iron ring main, with wrought steel flanges. Owing to the diverse nature of the shipyard demand, it was decided to supply both direct and three-

§ *Electrical Review.* New York, July 8th, 1905.

phase current at a number of different voltages; there is therefore a 450 volt. direct-current system, which with three wire distribution gives 225 volts., also a 110 volt. system chiefly for portable electric tools, and a three-phase 440 volt. 60 cycle supply. The engine-room contains three Sulzer tandem horizontal triple expansion engines of 1,000 h.-p. each, but capable of carrying a 25 per cent. overload. The cylinders are high pressure 17·3 in., intermediate 27·5 in., and low pressure (2) 31·5 inches by 47¼ in. stroke, the speed is 170 revolutions per minute; there are two cranks, one with a high and low pressure cylinder in tandem, and the other with the intermediate and a second low pressure cylinder. Two of these engines drive two generators each, viz., a three-phase alternator and a direct-current generator, while the third drives a three-phase alternator only. In addition, there are two high-speed engines, one driving a 350 kilowatt three-phase generator, and another a 250 kilowatt direct-current generator, there is also a 120 kilowatt synchronous motor driving two 60 kilowatt direct-current machines, which, besides balancing the three-wire network, serves as a connecting link between the alternating and direct-current supply. When only the three-phase generator is working, the synchronous motor drives the small direct-current machines supplying the small amount of direct-current required, and when only the direct-current plant is working the reverse takes place. The reason for driving two generators with one large Sulzer engine is that there are times when the total demand for both direct and alternate current does not exceed the capacity of one engine. In the basement is placed the surface condensers and auxiliary machinery, the former have an area of 870 sq. ft., and are cooled by water drawn from the harbour. Weir feed pumps are used, and the feed water is passed through two live steam heaters. No economisers are installed, and the circulating pumps, &c., are motor-driven. A storage battery of 112 chloride cells having a capacity of 1,530 ampere hours is also installed. There are 23 three-phase and 37 direct-current feeders radiating from the generating station to various parts of the works. Individual motors have as far as possible been applied to the tools, the bulk of them being three-phase motors. These were preferred because it was thought that the maintenance would be lower than for direct-current machines. When variable speed was required, and for hoists and cranes, direct-current motors have been fitted.

Electric Power in an Iron Foundry.*

THE Troy Malleable Iron Co., Watervliet, N. Y., U.S.A., has installed 39 three-phase motors having an aggregate horse-power of 306½ to replace two steam engines, one of 225 h.-p. and one of 125 h.-p., also 350 ft. of main shafting. The shafting losses were found from indicator diagrams to be 85 h.-p., and the steam drive was found uneconomical and inconvenient. Power is now purchased from the water power generating stations at Spiers Falls and Mechanicsville, N.Y., and is three-phase 40 cycles, transmitted at 20,000 volts. and stepped down to 2,200 volts for local service and further reduced at the works to 220 volts between lines giving 127 volts per phase for lighting. In order to eliminate troubles due to dust, polyphase motors of the short-circuited rotor (squirrel cage) type, have been fitted for all except the elevators, as they have only two bearings, which can be made practically dust tight. This type of alternating-current motor has many advantages. Starting is effected either through starting compensators in the case of larger machines, or by simply switching the machine directly on the line in the case of small machines. All the motors are fixed on the roof trusses, as it is found that their aggregate weight does not exceed that of the shafting, pulleys, &c. In the case of the cupola fans, these are motor driven, but one of the old engines is retained as a stand-by. Lighting is effected by 30 seven-and-a-half ampere arc lamps, and 600 sixteen candle power incandescent lamps. The power expenses of the factory have been reduced by 30 per cent. since the introduction of electricity, much valuable space has become available for other purposes, and owing to the convenience of having the independently driven machines in more favourable positions, the actual cost of manufacture has been reduced.

Electrically Driven Rolling Mills.†

HERR ILGNER'S work in connection with electrically driven rolling mills is well known on the Continent, several such mills being equipped with his system. Owing to the violent fluctuations in the load, electrically driven rolling mills present features of special interest, and it is not possible to operate such mills from public supply mains without the intervention of something to

* *Electrical Review*. New York.

† Paper by Karl Ilgner to the Society of Engineers and Architects, Vienna.

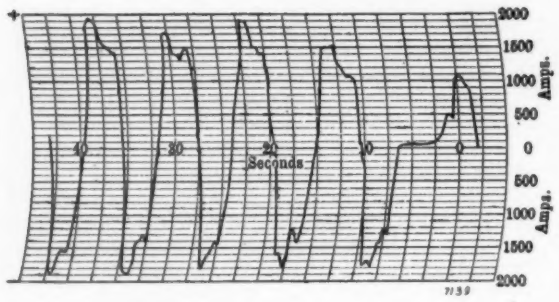


FIG. 2.—FLUCTUATIONS OF THE LOAD ON ROLLING MILL MOTOR.

serve as a buffer, as the fluctuations would entirely destroy the pressure regulation. Herr Ilgner's method is to instal a motor generator provided with a very heavy fly-wheel, the motor being supplied from the works generating plant or the public supply, and the generator side supplying the current to the mill motors. As the load comes on when the bloom enters the rolls the shock is taken by the generator and the fly-wheel, the latter slows down, and in so doing gives back a considerable amount of its kinetic energy to the generator: This fly-wheel should consist of a solid steel casting with a maximum peripheral speed of 295 ft. per second. Such a wheel weighing about 34 tons, and running at the angular velocity mentioned, can give out 7,500 h.-p. for about five seconds with about 15 per cent. reduction in speed, which is in fact more than necessary to pass a 2½ ton bloom once through the mill. The motor side of the motor generator, in accelerating the fly-wheel, stores up energy in it when the mill is running light or stopped, so that kinetic energy is available for the next pass. Fig. 2 shows the fluctuations of the load on the rolling mill motor, and was taken primarily with a view to ascertaining how quickly the mill could be reversed. It will be noticed that reversals were made in three and-a-half to five seconds. Experiments with a view to obtaining the power required in rolling were made at the Gutehoffnungs Steel and Iron Works, and are shown graphically, Figs. 3 and 4‡; the former relates to a 2¼ ton, and the latter a 3½ ton bloom. The speed of the rolls varied from 5 to 11 ft. per second, and the horse power required while the work was passing through the rolls, varied from 6,400, when the bloom

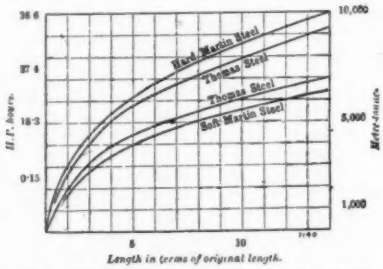


FIG. 3.—WORK DONE IN ROLLING 2·2 TON BLOOMS OF VARIOUS MATERIALS.

was first passed through, to 1,200 h.-p. after the fourth pass, when the bloom, which was originally 6 ft. 6 ins. long and about 21 ins. square, had been rolled to 131 ft. long by 4¾ ins. square. It was stated that for every horse power hour required at the rolling mill 2 h.-p. hours had to be supplied to the motor side of the motor generator, but owing to the great stand-by losses of the steam-driven mill, even with this loss in the motor generator the electrically driven mill was superior. This system is also in use at the Bethlen-Falva Iron and Steel Works, Schwientochlowitz, where the roughing, intermediate, and finishing trains are so driven.

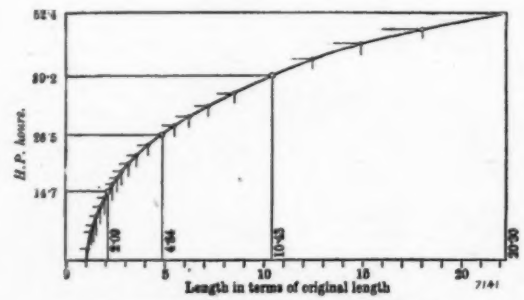


FIG. 4.—WORK DONE IN ROLLING A 3·5 TON BLOOM.

‡ From *The Electrician*. London.

Regenerative Control on Electric Tramways and Railways.§

An article dealing with some tests of Mr. Raworth's system of regenerative control, and experiments extending over about five months on the Yardley section Birmingham tramways, from which all series parallel cars have been withdrawn and regenerative cars substituted. Regeneration has frequently been tried but found difficult from a variety of reasons; the system now in use on a four mile section of the above tramways, is said to eliminate all the undesirable features of the older systems. Forty-one cars are so equipped, and as the Yardley route is entirely independent of the other sections, accurate measurements of the operating costs were possible. The energy required fell from 1·2 Board of Trade units per car-mile, with series parallel control, to ·97 unit with regenerative control, a reduction of almost 20 per cent. in the cost of energy; the repairs to trucks including new wheels, &c., came out, with series parallel control, at ·077*d.* per car-mile, with regenerative control ·016*d.* Still more remarkable was the fact that no new brake blocks were fitted during the five months, and the item for car examination and adjustments fell from ·063 to ·005 pence per car-mile. There has been no electrical troubles during the period in question. The simplicity of the system is another valuable feature; the brakes themselves are merely used for holding a car at rest on a gradient, the retardation being effected by the braking effect of the motors which are at the same time returning current to the line: as the acceleration and retardation is effected by moving one handle only, the work of the motor man is much simplified. A recent improvement is a controller which enables regenerative action to be obtained by retaining the series motors fitted on most electric tramcars. Hitherto, shunt motors have had to be fitted for this purpose. Mr. Raworth claims that remarkable as the results have been on tramways, still more remarkable results can be achieved on railways, where the enormous energy at present wasted in braking heavy trains can be recovered, and the wear and tear of the trucks, wheels, and brake shoes considerably reduced by adopting regenerative control.

Tramway and Railway Monopolists.—It is to be regretted, as a matter of principle that municipal opposition to the North-Eastern Railway Bill has given a modified form of veto to local authorities with regard to motor omnibus services. Of course, the idea in the present case is to protect the Corporation tramways of Newcastle and Hull from possible competition. We abstain from discussing the question whether municipal bodies ought to establish tramways or not, but hold the opinion that having elected to become traders, they should expect competition, and ought not to be accorded monopolist privileges. Unless we can have free trade in traffic facilities and other services for the good of the public, progress must necessarily be retarded. Railway companies are just as bad in their way as municipal bodies, for they fight tooth and nail to oppose every newly projected line. The purely commercial opposition of the Great Eastern Railway to the North-East London Railway is a case in point. There never was a more needed line than this, and it is an absurd position that a rival company should be allowed to oppose a measure intended for the convenience of the public. Fortunately this Bill has been reported for third reading, but the opposition has involved expenditure to both parties that would be better employed in productive works than in lawyers' fees.

The Proposed National Water Board.—Suggestions have been made at various times that the control of sources of public water supply should be vested in a central organisation. At a meeting of the Royal Sanitary Institute, Professor Sims Woodhead referred to the difficulties attending the provision of good drinking water for rural districts, not the least among these being the selfishness of local authorities and the indifference exhibited by them towards their neighbours. The subject is one of much importance to the inhabitants of cities and large towns deriving supplies from surrounding rural districts where the water used is sometimes little better than dilute sewage. We quite agree with Professor Sims Woodhead that the time has come for the constitution of a central authority with county committees empowered to control all public water supplies and to prevent the contamination of possible supplies as now happens all over the country.

§ *Electrical Investments.* London, July 19th, 1905.

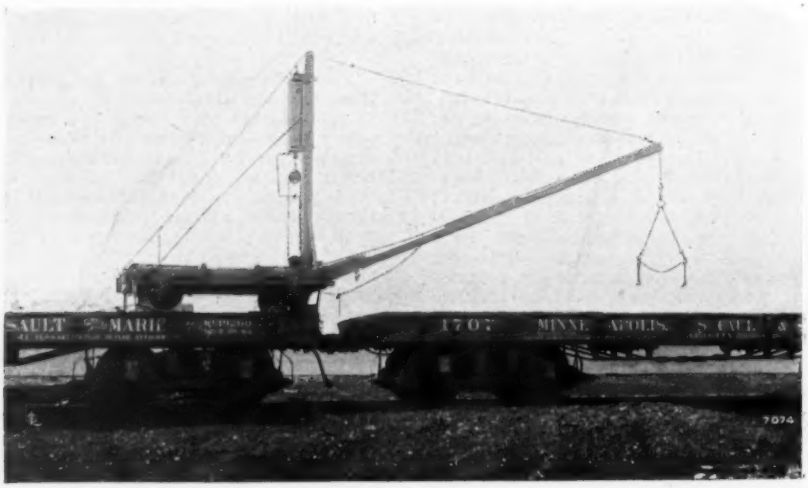
ENGINEERING PROGRESS

A Rail Loading and Unloading Machine.

THE accompanying illustration represents a machine which was designed specially for the work of loading and unloading rails rapidly and economically, and which is being used by a number of railways for this and other similar work. It consists of a crane or derrick operated by a pneumatic cylinder on the mast and attached to a car which travels along the train. The hoist is operated by compressed air, furnished by the air-brake pump on the engine, the train brakes being cut out and the air taken by the machine direct from the main air-pump reservoir. By the use of a three-way cock on the engine the engine brakes can still be operated, so that the train is under control at all times. The hoist has a clear lift of 14 ft., and a maximum reach of 19 ft. from the centre of the rails.

The loader can be operated successfully on flat cars, as well as cars with drop ends or permanent ends, and can easily be shifted from car to car as is required, as it is equipped with two sets of wheels—one set, fixed flat-faced wheels for use in moving it along flat cars and through gondolas with drop ends; the other set, of double-flanged wheels on telescope axles for running along the sides of cars with fixed ends. These latter wheels can be instantly adjusted to any width of car, also to run over the sides of cars that are bulged in the centre. The loader can easily be turned around on a flat car so that it can be operated from either end of the car. It can be shifted from car to car, and can be secured ready for use in an average of from five minutes to eight minutes.

The machine is secured to the car upon which it rests by chains with hooks which fasten under the car sills and are tightened quickly and securely by turnbuckles.



RAIL LOADING AND UNLOADING MACHINE.

The machine can be set up ready for work in thirty minutes after being dismantled, and the mast can be lowered or raised in four to five minutes.

The full crew to operate this machine rapidly consists of five men, as compared with twenty to twenty-six men for loading rails by hand. This gives a great saving over working with hand labour, especially when the work train has to run long distances or to spend much time on the siding to allow trains to pass. It also eliminates the liability of accidents to the men, as well as the liability to kink or damage the rails. It is stated that an experienced crew can load or unload rails on one and three-quarters to two miles of track per day, with ordinary delays, and distribute the new rail near the track in the best position for laying, with the head uppermost, as well as loading the old rails in tiers ready for shipment. The best results are obtained while the train is moving at a speed of about three-quarters of a mile an hour, and one hundred rails per hour is given as a fair average for loading or unloading with a trained crew and ordinary delays. The machine will operate successfully on curves, and in loading rails that have rolled down embankments, also in loading or unloading rails from stock cars. This machine is built by the United Supply and Manufacturing Company, 1535, Railway Exchange Building, Chicago.

The Sectional Steamer "Pontonier."

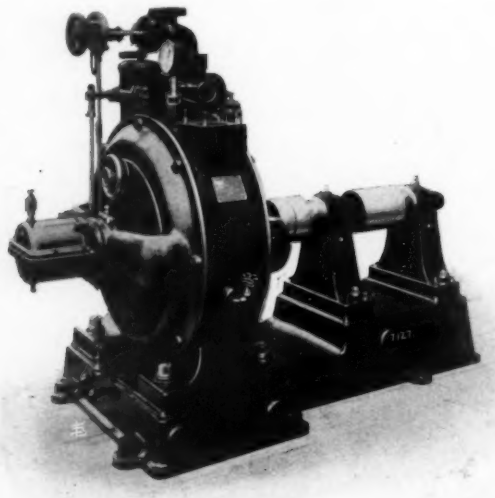
A UNIQUE and interesting sectional steamer has recently been constructed for the United States Engineer's Office of the Army Department. Nothing of an exactly similar nature has hitherto been constructed making this boat of particular interest, as it will be noted that the parts are arranged so as to be readily put together, and are self-locking. The *Pontonier* is built of steel, and is 80 ft. long, with a draught of 3·5 ft., and a beam of 18 ft. She has a displacement of 72 tons, and operates at a speed of eleven knots per hour. The section containing the engines has a space cut off fore and aft 11 ft. 5 ins., with an inside bulkhead for the officers' quarters. The sections are fitted with cones 1 ft. 2in. diameter. In the section next to the engine is a Seabury water-tube boiler installation and storage tanks for water, and fuel bunkers for 16,000 lbs. of coal. The engine section contains two double-cylinder compound engines with 9 in. stroke, the high pressure cylinders measuring 6 ins. diameter, and the low pressure cylinders 12 ins. The section ahead of that containing the boiler installation has quarters for a crew of twenty men, and also serves as a hold for the cargo, while the bow section has the necessary store lockers and carries the chain and anchor equipment, as well as a derrick. The boom and derrick mast provided have a capacity of 12,000 lbs., the forward deck also having hatchways, which are provided with watertight covering flush with the deck. There are two light boats with davits on the steel deck, which is constructed to carry a load of 20,000 lbs., concentrated on a truck of four wheels having an 8 in. wheelbase. There is a windlass on the deck of each section, and a steel cable to connect the section bolts being used for reinforcement, and when the

THE SECTIONAL STEAMER "PONTONIER."

THE SECTIONAL STEAMER "PONTONIER."

steel deck is in place, each section of the steamer becomes a watertight compartment.

It is stated that this type of vessel will be of special service for the prompt handling of troops and munitions in time of war. The necessary war material, provisions, and men being easily transferred from the army transport to any coast where it is necessary to effect a landing. The *Pontonier* will be utilised, it is said, by the War Department Engineers for general drill purposes in Washington at the United States Engineer School of Application, and the men will be thoroughly trained to transport troops and army material from ships to shore with the greatest speed and safety.



40—60 H.P. "ELEKTRA" STEAM TURBINE, WITH PULLEY-GEARING 13 ATMOS., 3,000 R.P.M.

The Elektra Steam Turbine.

THE Elektra steam turbine, the invention of Herr Kolb, of Karlsruhe, Germany, is being brought out by the Gesellschaft für Elektrische Industrie. Among the special points claimed for this novel turbine is the fact that it has neither the very high speed of the de Laval turbine, nor running wheels of very great diameter liable to set up high stresses in the material. It further does away with a large number of running and guiding wheels necessitated in the Parson's turbine and similar types.

The Elektra turbine is of the radial action and free jet type, the single stage types having only one pressure stage and several speed stages with double charge. The expansion energy of the steam for the whole available pressure

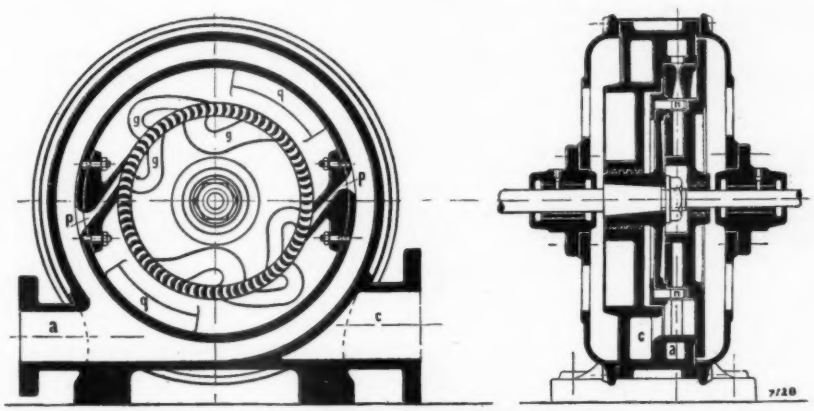
gradient is converted into speed in two expansion nozzles arranged diametrically in front of one another and is yielded to the rotor, which the steam traverses as many times as there are speed stages.

The compound turbines are likewise radial free jet turbines, having, however, two pressure stages, which are subdivided in turn by speed stages. Owing to the special shape of the steam conduits, the running wheel revolves at a relatively low speed, thus ensuring the same result as obtained in other types of turbine, either by transmission or by running wheels of large diameters or else by arranging a whole set of running and guiding wheels.

The turbine proper is surrounded by a housing into which two concentric steam channels have been cast, one of which serves for the admission of live steam and the other for the discharge of the exhaust. From the live steam channel, the steam is suppled to the running wheel by means of two nozzles lying opposite one another. In these specially shaped nozzles, the whole of the steam pressure is converted into velocity. The steam flows through the running wheel into a nozzle lying opposite and is led on in its direction until it once more strikes the running wheel, again to pass through an opposite nozzle, which a third time terminates in the running wheel. After again traversing this, it penetrates into a further nozzle, whence it passes for a fourth time through the running wheel, after which it flows into the exhaust channel. The same process can obviously be continued still farther.

The steam channels are broadened gradually as the speed of the steam decreases. As the turbine works as real pressure turbine, there are no pressure differences and corresponding losses in the interior of the engine.

The system of conducting the steam results in a relatively low speed of the running wheel; while peripheral speeds of 200 to 400 metres are quite common in connection with running wheels of other turbine systems, the Elektra turbine has running wheels of at most 80 to 100 metres peripheral speed.



DETAILS OF "ELEKTRA" STEAM TURBINE.

A sensitive governor is provided, working very rapidly in the case of a charge or discharge. The regulation valve has been so arranged as to ensure a satisfactory working even with small loads, and there is further a rapid locking mechanism preventing the standard number of turns being exceeded to any considerable degree.

Elektra turbines are readily connected direct to rotary or continuous current dynamos, but are being used as well to advantage in connection with centrifugal pumps and blowers to which they are directly connected. As a two-wheel turbine is readily constructed as a reversing turbine, it is rendered suitable for the propulsion of steam launches or steamships as well as for the operation of hauling plants.

A Turbo-Electric Locomotive.

A RECENT specification sets forth a proposal by Mr. Hugh Reid of the North British Locomotive Co., Limited, for an electrically driven locomotive, the current for which is supplied by turbine driven generators carried on the engine itself.

In spite of the roundabout path by which the heat energy of the fuel is finally utilised, there are numerous advantages attaching to the proposed engine in certain circumstances over those at present used; for example, it would be of particular advantage in localities where water is scarce by reason of the employment of a condenser, and since its mechanism may be readily enclosed, in countries where dust storms are prevalent, or where the winter is severe. Again, owing to the high economy of the combined turbine and condenser, aided by the utilisation of the hot water of condensation for boiler feed, and of the heat given up to the air in the condenser, it is claimed that an economy of fuel and a smaller steam consumption would be obtained than in the case where reciprocating non-condensing engines were employed for driving the dynamos generating current for the propulsion of the locomotive. Further, owing to the contamination of the water of condensation with lubricant, even if a condenser were possible, it would be inexpedient to use it.

In carrying out the invention according to one example particularly adapted for the working of heavy goods and passenger trains over long distances, the following design is employed, illustrated in Fig. 1.

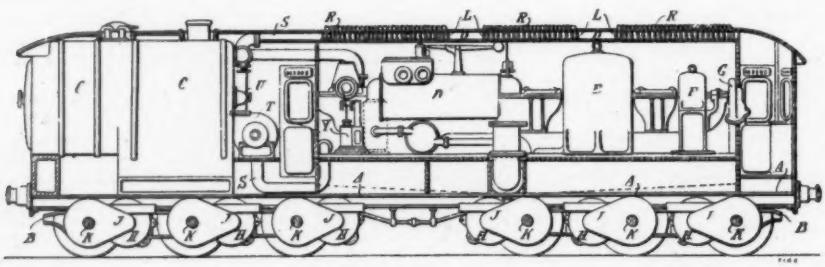
A is a truck, carried upon two bogies, *B*, a boiler, *C*, of modified locomotive type, supplying steam to a turbine, *D*, of Parson's type. The latter is directly coupled to an electric generator, *E*, of the multi-phase type, and also to an exciter, *F*, for the generator and to a centrifugal air pump, *G*.

The generator, *E*, supplies current to a series of similar motors, *H*, geared to the axles, *K*, of the bogie wheels. The condenser, the surfaces of which are cooled by a current of air drawn over them, consists of three series of tubes arranged along the sides and over the top of the structure enclosing the mechanism. The tubes are connected at opposite ends to two headers, *M*, *N*, to one, *M*, of which exhaust steam from the turbine, *D*, is led and in the other, *N*, of which vacuum is maintained by the centrifugal air pump, *G*, the water of condensation being discharged into a hot well, from which the boiler is fed by feed pumps, *W*, of ordinary reciprocating type. A pump, *V*, maintains forced lubrication of the various bearings.

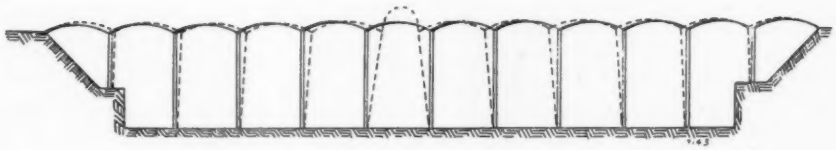
The set of tubes, *L*, are enclosed in casings, *O*, and each casing is fitted with a series of louvres, *R*, *R*, through which a current of air is caused to flow opposite.

The air passing in at the louvres passes over the tubes, *L*, condensing the steam therein and itself becoming heated. The exit louvres over the series of tubes in the casing nearest the boiler, and to which the exhaust steam first has access, are normally kept closed, and the air, heated in its passage over what are thus the hottest tubes of the condenser, is led from that casing to the firebox of the boiler, *C*, by ducts, *S*.

When the locomotive is in motion, the velocity thus given to the air is normally sufficient to maintain a blast pressure in the furnace of the boiler, but in order to augment, when necessary, the pressure thus available, and to provide a current of air over the condenser surfaces when the locomotive is stationary, a fan, *T*, driven by an electric motor is provided. The outlet of the fan is connected by a two-way valve, *U*, to the ducts, *S*, so that the air can be either led from those ducts directly to the firebox, or drawn through the lower duct from the



TURBO-ELECTRIC LOCO.



MADRID RESERVOIR FAILURE.

condenser by the fan and forced into the fire-box.

The method of utilising the air which has first taken up heat in a condenser to maintain a draught in the boiler would appear to be advantageous, in that the air used for maintaining this draught has obtained its heat from the steam condensed makes for high thermal efficiency—an efficiency not so economically obtainable by air otherwise heated and after latent heat of the steam or of the waste furnace gases has been lost.

The Madrid Reservoir Failure.

REFERRING to the failure of the concrete-steel reservoir at Madrid, *Beton und Eisen* remarks that in addition to the slender proportions of the arched covering of the reservoir there is a further consideration that may very easily account for the destruction of the arches. The cross section, reproduced on this page, shows the actual proportions of the work in question, and indicates the manner in which unsymmetrical loading may bring about dangerous displacement of the arches and the supporting columns. But in addition, it is pointed out that during the day on which the catastrophe occurred, an altogether abnormal temperature variation was observed, the effect of which would be to still further increase the characteristic distortion of the arches, especially as no provision for expansion had been made. This explanation deserves to be considered, because, whether failure actually occurred or not by reason of the influences here suggested, it gives a hint that ought to be taken by all engineers who are concerned in the design of similar structures. The same effect of unsymmetrical loading is generally evidenced in a slab, while in the case of an arch the risk of dangerous deformation owing to one-sided loading remains in question until the spandrel filling has been placed in position, and makes it necessary to exercise the greatest caution.

Power from Sewage Slime.

HERR VON HORSTIG, in a recent number of *Zeitschrift des Vereines Deutscher Ingenieure*, describes the lignite pulp sewage process, designed by Degener, where any solid substances are precipitated by means of brown-coal pulp and perfectly separated from water, while the sewage can be disinfected as desired by adding chloride of lime. The whole process is so rapid in its action that there is no possibility of putrefaction being produced, the precipitated slimes being perfectly inodorous. This process is no doubt the most satisfactory from the sanitary point of view. In operation it is as follows:

After having been conveyed from the collecting pit by means of pumps into the mixing launders, the brown coal pulp (about 1 to 1·5 kgs. per cub. metre) is admitted and some sulphate of aluminium or iron added, so as to cause any dissolved components to coagulate. After being mixed in the launders the substances will get to a bell, where any sinking bodies are readily separated while air is being drawn from the bell. The precipitating bodies will constitute a real filter, through which any subsequent particles are not allowed to penetrate, when the water will flow in a quite clear condition into a basin in the cupola and through a pipe into a small disinfecting launder, where chloride of lime (12 grms. per cub. metre of sewage) is added if necessary.

As regards the means of carrying out this most satisfactory but rather expensive sewage disposal process in such a way as not to work out at any heavier cost than any other processes, this can be done by burning the slimes which consist of from one-quarter to one-third of brown coal and utilising the heat thus generated. To this effect, the slimes are freed of part of their water by means of filters and the dry and inodorous mass sold as fuel, or else burned under steam boilers or converted into gas in gas producers.

According to the experience so far gained, 1 cub. metre of sewage will contain 4 to

6 kgs. of slimes, holding 58 to 60 per cent. of water, and 1 to 1½ kgs. of brown coal. The organic components of the sewage are carbon, hydrogen, oxygen, and nitrogen. The fact that they are combustible and that combustion will avoid any drawbacks to which all the other processes otherwise may give rise, has been borne out by conclusive tests. A producer gas plant is in course of construction in Oberschöneweide, near Berlin, where the tests the Gas Motor Works Deutz are engaged in are to be continued. According to experiments so far made, 2 kgs. of slimes will yield 1 h.-p. hour. This would work out, *e.g.*, at about 2,500,000 h.-p. hours per year for the town of Spandau, near Berlin, which has been provided with a Degener sewage disposal plant.

According to the author a yearly benefit of about 85,000 marks would be obtained, deducting the expenditure of the power station so as to nearly wholly compensate the cost of the clearing process.

Torpedo Boat Destroyer "Magne."

THIS vessel forming the subject of the accompanying illustration is of the *Shirakumo* type, which has proved itself so successful in the present Russo-Japanese war. She was built for the Swedish Government by Messrs. John I. Thornycroft & Co., Limited, and was launched on the 2nd ult., undergoing successfully a preliminary trial nine days after launching. The following are some of the leading particulars of the vessel :—

She has a guaranteed speed of 30½ knots, to be maintained for three hours with a load of 55 tons on board.

The vessel is 219 ft. 9 in. long overall, 20 ft. 9 in. beam, and has a draft of 8 ft. 3 in. at the screws.

The machinery, which is over 7,200 I.H.-P., consists of two sets of four-cylinder vertical triple compound condensing engines and four "Thornycroft" water-tube boilers, worked under forced draught on the closed stoke-hold principle.

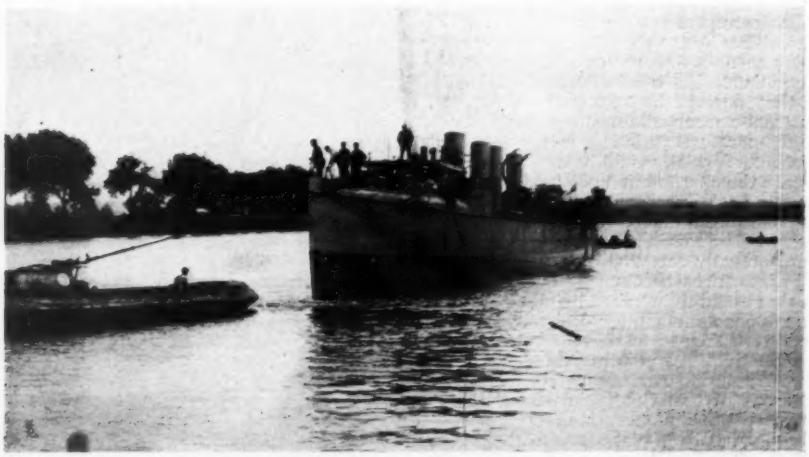
The bunkers have a capacity for 80 tons of coal, giving a radius of action of 2,800 nautical miles at a speed of 15 knots per hour.

A signal mast with derrick, topmast, and yard is fitted forward, and can be hinged down on deck when desired.

There are three boats carried on davits, one being a "Thornycroft" petrol motor gig, 22 ft. long with 10 B.H.-P. motor, the other boats are respectively, an 18 ft. cutter and a 14 ft. dinghy.

Accommodation is provided for sixty-four officers and men, each officer having a separate cabin.

The armament consists of six 57 mm. quick-firing guns, one mounted on the conning tower, one aft, and four on the



TORPEDO BOAT DESTROYER "MAGNE."

broadside. There are also two 45 cm. revolving torpedo tubes.

The boat is extensively subdivided into water-tight compartments by transverse bulkheads and water-tight decks under the living spaces.

An Improved Method of Absorbing Gases.

A REMARKABLE discovery of exceptional importance is that recently made by Professor Dewar, and its almost immediate industrial application to the production of high vacua and the separation of gases renders it all the more noteworthy.

The method relates to the well known quality possessed by charcoal of being able to absorb many gases. When heated to a red heat and exhausted to free it from its naturally contained gas it is capable, on cooling to the ordinary temperature, of absorbing traces of gas left in a virtually vacuous space. Professor Dewar found, however, that charcoal is rendered a better absorbent of gases when it is cooled to a temperature comparable with that at which the gas to be absorbed boils. For example charcoal at the temperature of 0° C. will absorb 4 c.c. of hydrogen or 18 c.c. of oxygen. When it is cooled to —180° C. it will absorb 135 c.c. of hydrogen or 230 c.c. of oxygen, both measured at 0° C. One application of this is for the production of high vacua. If, for example, a vessel containing air to be exhausted, as in the manufacture of incandescent lamps or of Rontgen tubes, be put into communication with a mass of charcoal which is cooled, the charcoal thereupon absorbs the air from the vessel, which is correspondingly exhausted. For a nearly complete exhaustion the charcoal should be at a temperature about the boiling point of air. By cutting off communication between the vessel and the charcoal while the latter is still cooled the exhausted condition of the vessel is attained.

Professor Dewar has further discovered that cooled charcoal exercises a selective action of absorption on mixtures of gases, absorbing some in preference to others, in such manner that practical separation may be obtained in one or several treatments. As an example of this, when dry air in excess of that required for saturation of the charcoal is passed over it at —180° C, the mean composition of the absorbed gases will be 56 *per cent.* of oxygen and 44 *per cent.* of nitrogen, further fractionation may be obtained of such absorbed gas, by slowly raising the temperature of the charcoal, when the air absorbed by the charcoal will be expelled slowly and may be collected in separate fractions, each richer in oxygen than the preceding one. In this manner oxygen or nitrogen may be obtained. By a similar proceeding to the above fractional separation of mixtures of gases and vapours is possible. Thus by cooling charcoal to —80° C and passing coal gas over it which has been previously cooled to the same temperature in order directly to separate all the condensible constituents, it becomes charged with the gaseous hydrocarbons and allows the hydrogen and carbonic oxide to escape. On heating the charcoal it evolves these concentrated and gaseous hydrocarbon vapours.

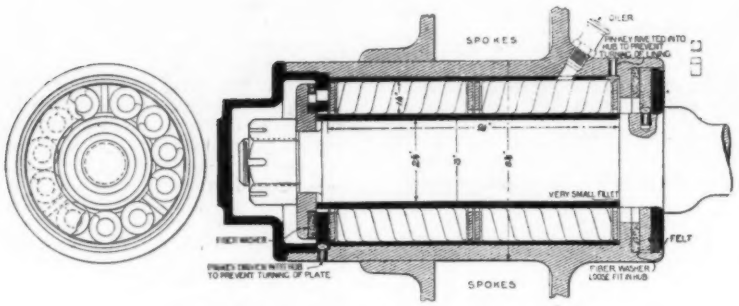
Other gases may be similarly separated or absorbed for making high vacua. Instead of allowing the gases absorbed in the cooled charcoal to expand to the ordinary atmospheric pressure the operation of heating may be conducted in closed vessels when the gases will be obtained under pressure and can be so stored for use.

Flexible Bearings for Automobiles.

THE position of the friction reducing bearing is now firmly established, and the question occupying the mind of the designer is what particular type of this class of apparatus is best adapted to the work in hand. Recently, and particularly in connection with automobile work, the flexible roller type has come prominently to the fore, embodying as it does features which render it particularly suitable for that class of duty.

The Hyatt flexible roller consists essentially of a spring, and is made by winding a steel strip of special composition into a roller, varying the dimensions of the strip, depending upon the conditions of speed and load under which the roller is to operate. It will be readily seen that a roller of this construction has all the advantages of a solid roller, and, in addition, has the element of flexibility, which enables it to more closely conform to the irregularities that are always present in the actual operations of any bearings.

This flexibility permits a uniform distribution of load along the entire length of the roller, or, in other words, we have a full line of contact as compared with a series of points in the case of a ball, or greate



THE HYATT FLEXIBLE BEARING AS ARRANGED FOR HUBS.

number of points in the case of a solid roller.

It will also be noted from the construction of this roller that it acts essentially as an oil reservoir and its spiral formation acts as an oil carrier; the result is that there is a constant travel of lubricant from one end of the bearing to the other, requiring all parts to be properly lubricated at all times. The spirals being made both right and left hand, any dirt or grit which enters the bearings is immediately forced through the spiral openings and collects inside, where it does not interfere with the operation of the roller.

While the Hyatt bearing has for some time been successfully applied to sleeved axles, shaft driven axles, chain driven rear axles, both in small cars and heavy 'buses and lorries, its application to hubs was only taken up a little over two years ago. A number of designs have been introduced, some of which have been taken up by various manufacturers, but slight changes have been found necessary in the first design brought out. The fact that the usual spindle is forged from ordinary soft machinery steel, has proved the desirability of using a spindle of higher carbon or one that has been case-hardened if the Hyatt roller is to operate directly on the spindle itself; in other cases it is quite feasible to provide the spindle with a thin Hyatt sleeve, which has greater wearing surface, owing to its high carbon. This design also makes it possible to make renewals or repairs without any difficulty.

As applied to heavy lorries, we understand that the Yorkshire Patent Steam Wagon Co. and Messrs. Alf. Dougall & Co., Ltd., of Leeds, are using these bearings applied to sleeved axles with conspicuous success on 3 to 5-ton motor lorries. Further, the new car recently brought out by the Phœnix Motor Co., of Southport, is fitted with Hyatt bearings on the countershaft, and the same is said to have given every satisfaction.

METALLURGICAL PROGRESS

By PERCY LONGMUIR,
Carnegie Research Medallist.

Iron and Steel.

*New Open Hearth Steel Processes**.—Mr. P. Ackers in a paper read before the Mining and Metallurgical Congress, Liége, traces the development of the open hearth process of steel making and notes the more salient features of the newer methods. The advantages of liquid pig iron are illustrated by an example from the Jurjewka Works, Donetz. There are five furnaces of from 25 to 30 tons capacity, and they are charged with liquid metal from a 150-ton mixer. During July, 1904, these furnaces produced 13,754 tons of good ignots on a working equal to 140 days and 570 charges; in other words 98 tons of steel per 24 hours per furnace. The working of a charge occupied 5½ hours from charging to tapping, the analysis of the pig iron used and that of the finished steel being as follows:—

	Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.
Pig iron...	4·25	1·17	2·80	0·03	0·20
Steel	0·07	0·01	0·50	0·03	0·04

Five thousand kilos of slag were produced containing 0·46 per cent. phosphorus and 8·1 per cent. iron. The latter corresponds to a loss of iron equal to 405 kilos. Iron reduced from the ore resulted in a gain 1613 kilos over the weight of pig iron charged, that is a yield 106 per cent.

The author also reviews the Bertrand Thiel, Talbot and Surzycki processes, all of which have been recently noted in these columns. Finally in summarising the advantages of liquid pig iron the following broad conclusions are drawn:—(1) Economy of labour in handling the output of the blast furnace and in charging the steel furnace. (2) The reduction of time in working the charges results in an increased production per furnace. (3) The scrap problem is to some extent eliminated. (4) Steel works reap the advantages of power from the gases of the blast furnace. (5) Greater fuel economy.

Recent Advances in the Electro Metallurgy of Iron and Steel.† — The application of the electric furnace in metallurgy may be said to be largely founded on experience gained in the manufacture of calcium carbide. Carbide furnaces are largely used for the production of rich ferro alloys such as ferro chrome and ferro silicon. The satisfaction of this demand led to certain efforts towards the direct reduction of iron ores. Whilst direct competition with the blast furnace is out of the question there are still certain advantages to be gained by electric heating, and although direct reduction is at present unremunerative there may be a future for it when the development of electric furnaces is more advanced. In the blast furnace one third of the coke charged is necessary for the chemical reduction of the ore, the balance being employed in producing the requisite temperature. Thus two thirds of the fuel can be replaced by electric heating. As an example the reduction of *pure* oxide of iron is taken.

Theoretically:—

1429 kilos. Fe_2O_3 } For the production of 1000
322 kilos. carbon } kilos. iron.

	Calories.
For reduction of Fe_2O_3	1,780,000
For heating and fusing iron—maximum	430,000
	2,210,000
By oxidation of 322 kilos. C to CO ...	778,000
,, ,, 322 kilos. C to CO_2 ...	2,603,000

Leaving to be supplied by electric power 1,432,000 = 1,657 K.W.H. = 2,220 H.P.H. = 0·253 H.P.Y.

Various electric furnaces are noted and a summary of the report of the Canadian Commission is given.

The Galbraith Electric Iron and Steel Furnace.—This furnace is designed to treat iron sands, and its chief features are as follows*:—The sand, mixed with carbon, enters the furnace in the form of a shower and follows a zig-zag path through a number of carbon grids which are heated by the current. The charge in its descent is met by reducing gases, and the reduced metal is collected in a receiver in the form of shot or beans. The furnace is sealed, thereby excluding air, otherwise the carbon grids would burn. Low potential currents are utilised and neither flux nor fuel in the ordinary sense is

* *Iron and Coal Trades Review*, July 14, 1905.
† R. S. Hutton, *Journal of the Society of Chemical Industry*, No. 11, Vol. xxiv.

* *Engineering*, July 21, 1905.

required. Previous to charging, the ore mixed with carbon (coal dust) is given a preliminary reheating. The furnace is built of a framing of graphite holding horizontal grids, also of graphite; the grid bars form obtuse angled roofs. Four grids are confined in one tier, and three tiers are arranged one above another, therefore the descending shower passes over twelve bars in succession. Between the bars intercepters are placed and which are the same form as the grids. The sand used and the resulting product is shown in the following table.

Ore.	Per cent.	Product.	Per cent.
Peroxide of iron ...	67·04	Carbon	2·891
Proto oxide of iron...	30·17	Silicon	0·201
Manganese peroxide	0·22	Sulphur ...	0·189
Alumina	0·16	Phosphorus ...	0·453
Silica	0·50	Manganese ...	0·137
Titanium	1·60	Copper	0·240
		Titanium ...	nil.

This is essentially a crude product, but if the furnace will solve the difficulty of economically treating fine iron sands by obtaining a product such as the foregoing—which will admit of further treatment—then assuredly it has a future in store.

Rail Sections as Engineering Structures.—In a memoir presented to the American Society for testing materials, Dr. Dudley discusses rail sections as engineering structures. The stiffness and strength of a section increase in a rapid ratio as the height is augmented as shown below.

Table I.

Weight of section in lbs.	Height in inches.	Width of head.	Moment of inertia 4th power. Inches.	Moment of resistance. Cubic inches.
60	4·0	2¼	12·0	6·7
65	4·3	2⅝	16·0	7·8
80	5¼	2⅝	28·5	11·4
100	6·0	3·0	48·5	16·6

The 80 and 100 lbs. section become more efficient engineering structures than the 60 and 65 lb. which they replaced by inducing a longer distribution of the passing wheel loads to the cross ties and ballast, and lessening the deflection under the wheels. The stiff sections for a given unit fibre strain, carry larger bending moments than the limber, and are therefore more efficient engineering structures for heavier axle and total loads.

Table II.—Positive Bending Moments in inch pounds for the given unit fibre strains per section in Table No. 1.

Section.	10,000 lbs.	20,000 lbs.	30,000 lbs.	40,000 lbs.
lbs.	Ins. lbs.	Ins. lbs.	Ins. lbs.	Ins. lbs.
60	67,000	134,000	201,000	268,000
65	78,000	156,000	234,000	312,000
80	114,000	228,000	342,000	456,000
100	166,000	332,000	498,000	664,000

Further considerations are given showing that the metal in the bearing surface of the stiff rails sustains two and three times the burden required by the former limber sections. Turning to the metallurgical aspect of the paper it is shown that the metal of a rail section has three functions to perform, viz.:—to receive, to support, and to distribute the wheel loads of the passing trains. The metal in the bearing surface sustains its loads chiefly by its properties of cubic elasticity and should be sound and homogeneous. The side of the head resists abrasion of the wheel flanges by its toughness and tenacity. To distribute the loads by the entire section its linear elasticity is exercised. In service a distortion of the rail head indicates a non-homogeneous steel and one of low cubic elasticity. With a solid steel of sound and fine texture the head will not distort under service though it wears on the bearing service and on the side. Rails made from unsound and spongy ingots give heads which flatten and crush under wheel loads. Further, if the top of an ingot is used, where by liquation the carbon and phosphorus

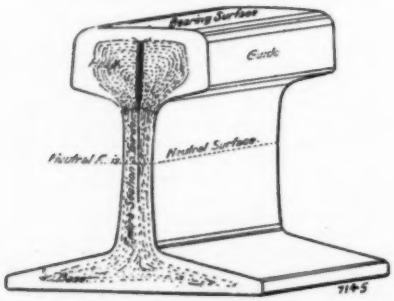


FIG. 1.—RAIL SECTION FROM THE UPPER PORTION OF INGOT, SHOWING A CENTRAL CORE OF METAL IN WHICH BY LIQUIDATION THE METALLOIDS IN THE STEEL ARE ABOVE THE AVERAGE.

FIG. 2.—RAIL SECTIONS AS ENGINEERING STRUCTURES.

are higher it results in a fragile centre core as in Fig. 1. Under other conditions the repeated wheel pressures develope a check which is equivalent to a pipe, and as the metal immediately over it stretches sideways by its linear elasticity, the check widens until it becomes detached from the web of the rail as in Fig. 2. Finally the author emphasises the necessity of sound ingots free from liquation, and possessing the requisite physical properties to resist distortion under traffic.

*The Problem of Small Bessemer Plant.**—Mr. F. W. Löhdorf reviews, in a very general manner, some of the difficulties attendant on the operation of small convertors. It is evident that, in considering steel-making processes, the crucible, which is one of mixing only, cannot be included in the same class as the Open Hearth and Bessemer. The two last are essentially producers in that the initial charge is pig iron and the product finished steel. The Open Hearth produces high quality steel, but the cost of installation is beyond a small works. The crucible, whilst inexpensive to install, is costly in operation, therefore, in this direction, small or "Baby" convertors have a good field, in that steel of good quality can be produced as required, and the plant is not costly in installation, operation, or up-keep, Various difficulties encountered in operating these convertors are traced by the author to faulty management or to non-appreciation of the essentials of the process. Given suitable management, these difficulties vanish, and the small convertor has a good future in store, especially in the case of small foundries.

Foundry Practice.

Steel in Cast Iron.—Various founders have doubtless encountered difficulties in melting steel with cast iron, and according to Mr. R. P. Cunningham† this is a matter requiring close attention, in order to obtain the best results. Thus, for thin castings, only a small percentage can be used, but this amount may be increased with the thickness of the castings, the slower cooling of a thick casting, resulting in a more open grain. The method of charging the cupola, in the case of a casting requiring 4,000 lb. metal carrying 25 per cent. steel is as follows:—The internal diameter of the cupola is 48 inches and the weight of the coke bed 1,200 lb. The first charge of pig iron is 1,000 lb., followed by 500 lb. steel, 500 lb. pig iron, 150 lb. coke, 500 lb. steel, 1,500 lb. pig iron. With the last amount of steel 1¼ lb of ferro manganese is added to each 100 lb. of steel, and the same weight of ferro silicon is added to the ladle. The writer has also found that by using two brands of pig, one high in manganese, the other high in silicon, and both low in sulphur, much finer grained castings result than when depending on ferro manganese or ferro silicon. Eighteen casts with varying percentages of steel showed a content of 33 per cent. to be the highest amount that could be used with advantage. Higher contents than this gave excessive shrinkage in the castings with only a slight gain in strength. For ordinary work 25 per cent. steel will give sufficient strength for all practical purposes, will machine easily and yet be close grained.

Notes on Pipe Foundries.—In a recent issue of the *Iron Trade Review*, Mr. J. B. Nau pays a compliment to European foundries. . . . "in many respects these foreign foundries are ahead of American practice. . . ." "This was more especially to be seen in pipe foundries." Commenting on the use of direct metal in conjunction with a mixer, the writer draws attention to its economy, and advocates American founders to follow the practice, in that with careful supervision it leads to good results. One advantage of direct metal from a mixer is in the lower sulphur content than for similar grade metal remelted in a cupola. Other salient features of pipe foundry practice are noted which confirm the opening statement.

General Metallurgy.

*Manganese Bronze.**—These bronzes are essentially yellow brasses containing greater or less amounts of manganese, iron and aluminium. Therefore an alloy of 60 per cent. copper and 40 per cent. zinc may be considered as a base, and castings of such an alloy will yield a maximum stress of eighteen tons per square inch with an elongation of 15 per cent. on 2 ins. The individual action of iron, aluminium and manganese is to raise these properties, that is when present in comparatively low quantities. When present, collectively a decisive increase in tensile strength and ductility results. Tests are given to show that the base of the alloy must approximate 60 per cent. copper and 40 per cent. zinc, in other words the loss of zinc during fusion must be made good before casting.

Metallurgical Research Laboratories.†—There are times when the commercial value of research is questioned by bringing forward the argument "does it pay?" As our contemporary very justly remarks: "experimenting is the price of progress." "The question 'will it work' is best answered by 'try and see.'" Experimental work, without organisation is hard to achieve, but with organisation it is easy. The essence of the whole matter lies in the perfect welding of theory and practice. Therefore a research department should be in intimate touch with practical operations. Such a department wisely and liberally administered by a progressive man is most valuable. Foolishly and extravagantly managed it is worse than useless. Here, as in all else, the personal equation determines the fate of the enterprise.

* *Giesserei Zeitung*, No. 8, Vol. ii.
† American Foundrymen's Association.

* P. Longmuir, *The Foundry*, June, 1905.
† *Electro-Chemical and Metallurgical Industry*, No. 7, Vol. iii.

In this section is presented every month a list of the principal contents of the leading organs of the technical press and of the proceedings of learned societies throughout Great Britain, the Continent, and America. An alphabetically-arranged list of the publications regularly reviewed, together with the place of publication and price, was given on pages 195—198 of the August issue.

CIVIL ENGINEERING.

Bridges.

Bridge over the River Zambesi. *Engineering*, 21*st July* and 4*th August*, 1905.

Cantilever Erection of Simple Riveted Railroad Spans. *Engineering Record*, 15*th July*, 1905.

Ballasted Bridge Floors. *Journal Western Society Engineers*, *June*, 1905.

Compressed Air Foundations for Bridges. No. 1. *The Engineer*, 4*th August*, 1905.

Maximum Bending Moments due to Rolling Loads. *Engineer*, 21*st July*, 1905.

Cantilever Bridge over the Mississippi. *Engineer*, 21*st July*, 1905.

The Deflection of Continuous Rail-Bearers. *Engineering*, 21*st July*, 1905.

North-Eastern Railway Co.'s Bridge over the River Wear at Sunderland. *Railway News*, 15*th July*, 1905.

The Superstructure of the Manhattan Bridge, New York. *Engineering Record*, 29*th July*, 1905.

The Newark Viaducts of the Lackawanna Railroad. *Engineering Record*, 22*nd July*, 1905.

Replacing a Four-Track Bridge under Heavy Traffic. *Engineering Review*, 29*th July*, 1905.

Note on the Maximum Loading of Bridge Members. J. Nassau. *Annales des l'Association des Ingenieurs sortie de Gand.* 1904. Vol. III.

Cantilever Bridge across the River Mattig, Austria. *Engineer*, 28*th July*, 1905.

Treskow Bridge at Oberschoneweide, near Berlin. *Zeitschrift des Vereines Deutscher Ingenieure*, 15*th July* and 5*th August*, 1905.

Canals, Rivers and Harbours.

Canal Transport. *Iron and Coal Trades Review*, 4*th August*, 1905.

The Panama Canal. Some serious objections to the Sea Level Plan. *Engineering News*, 27*th July*, 1905.

Irrigation.

On the Stability of Masonry Dams. By Karl Pearson, F.S.C. *Engineering*, 14*th July*, 1905.

Sir Wm. Preece and "The Navigation of the Nile." By Sir Hanbury Brown, K.C.M.G. *Engineer*, 14*th July*, 1905.

Stresses in Dams. *Engineering*, 4*th August*, 1905.

Masonry Dam for the Granite Springs Reservoir, Cheyenne Water Works. *Engineering News*, 29*th June*, 1905.

On the Distribution of Shearing Stress in Masonry Dams. *Engineering Record*, 22*nd July*, 1905.

Pile Foundation for Movable Dam, at McMechen, W. Va., with method of calculation. *Engineering News*, 27*th July*, 1905.

Miscellaneous.

Construction of Coffer Dams. *Proc. Engineers Society, West Penn., July*, 1905.

Failure of a Concrete Sea Wall. *Railway Gazette*, 4*th August*, 1905.

The Water Works Catastrophe in Madrid. The Failure of the Reinforced Concrete Covering of a Service Reservoir. *Engineering Record*, 22*nd July*, 1905.

Construction of Karawanken Tunnel, Southern Part. Conc. *Elek. Bahnen u Betriebe*, 14*th July*, 1905.

BUILDING.

Construction and Design.

Visintini Reinforced Concrete Truss Construction. *Railway Age*, 30*th June*, 1905.

Reinforced Concrete Chapel Building, U.S. Naval Academy, Annapolis, Ind. *Engineering News*, 13*th July*, 1905.

Underpinning a 70 ft. Wall without Temporary Supports. *Engineering Record*, 22*nd July*, 1905.

Building the Beachy Head Lighthouse. *Engineering Record*, 29*th July*, 1905.

Ferro-concrete Wharf at Dundee. *Engineer*, 28*th July*, 1905.

Rail Sections as Engineering Structures. *Railway Age*, 28*th July*, 1905.

Heating and Ventilation.

Heating System of the Fifth Regiment Armoury, Baltimore. *Engineering Record*, 1*st July*, 1905.

Flow of Air in Metal Pipes. Paper before American Society Heating and Ventilating Engineers. *Engineering Record*, 8*th July*, 1905.

Possibilities in Heating with Hot Air. *Engineering News*, 13*th July*, 1905.

The Design of Central Station Hot-Water Heating Systems. *Engineering News*, 20*th July*, 1905.

The Design of Centrifugal Fans. *Practical Engineer*, 21*st July*, 1905.

MEASUREMENTS.

MATERIALS.

The Strength of Reinforced Concrete. *Journal West. Society Engineers, June*, 1905.

Reinforced Concrete. Some of its Principles, with Practical Illustrations. *Proceedings Engineers' Club, Pa., July*, 1905.

Low-Pulling Portland Cements. *Engineering Record*, 8*th July*, 1905.

Tests of the Efficiency of Vertical Stirrups in Reinforced Concrete Beams. *Engineering News*, 6*th July*, 1905.

Curing Concrete Blocks. *Engineering Record*, 29*th July*, 1905.

Proper Methods in Conducting Painting Tests. *Engineering Record*, 15*th July*, 1905.

Investigation of the Effect of Heat upon the Crushing Strength and Elastic Properties of Concrete. *Engineering News*, 13*th July*, 1905.

Materials used in Furnace Construction. *Iron and Coal Trades Review*, 21*st July*, 1905.

The Fire Resistance of Different Concretes. *Engineering Record*, 22*nd July*, 1905.

Reinforced Concrete. Some of its principles, with practical illustrations. *Proceedings Engineers' Club of Phil., July*, 1905.

A Problem in the Storage of Granular and Lump Material. *Engineering News*, 27*th July*, 1905.

Dimensions of Rectangular and T-shaped Concrete Iron Girders. *Beton u Eisen, July*, 1905.

Calculating Concrete Iron Slabs. *Beton u Eisen, July*, 1905.

MECHANICAL ENGINEERING.

Boilers, Furnaces and Fuel.

Action of Gases upon Firebricks. *Journal Gas Lighting*, 18*th* and 25*th July*, 1905.

Boiler Furnaces. *The Engineer, Chic.*, 15*th July*, 1905.

Coal Conveying Plant. The Metropolitan Electric Supply Co.'s Works. *Engineering*, 14*th July*, 1905.

Heat Insulation, Paper before Faraday Society. *Engineering*, 14*th July*, 1905.

A Suction Gas Producer of Improved Design. *Engineer, Chic.*, 1*st July*, 1905.

Fractures in Large Steel Boiler Plates. *Engineering*, 4*th August*, 1905.

Smoke and its Abatement. *The Engineer, Chicago*, 1st *July*, 1905.

Flue Gas Analysis. *Electrical Review*, 14*th July*, 1905.

Passage of Heat through Boiler Heating Surfaces *Dingler's Polytechnic Journal*, 15*th July*, 1905.

The Smoke Nuisance and its Remedies. *Zeitsch. Oester. Ingr. Arch. Vereines*, 21*st July*, 1905.

Engines and Motors.

Trials of Gas Engines worked from Suction Gas Producers. *Journal of Gas Lighting*, 1*st August*, 1905.

Use of Superheated Steam for Reciprocating Engines. *Zeitsch. Vereines Deutsch. Ingr.*, 8*th July*, 1905.

Choice of Eccentrics with Double Valve Slides. *Zeitsch. Vereines Deutsch. Ingr., 8th July*, 1905.

Investigations of Steam Power Plant having Double Superheating by Exhaust Gases. *Zeitsch. Vereines Deutsch. Ingr.*, 15*th* and 22*nd July*, 1905.

Engines and Motors.

New Corliss Valve Gear. *The Engineer, Chic.*, 1*st July*, 1905.

2,000-k.w. Curtis Steam Turbine Tests. *Iron and Coal Trades Review*, 4*th August*, 1905,

Steam actuated Valve Gear. *Mechanical World*, 14*th July*, 1905.

Calculating the Steam Consumption of Steam Turbines. *Power, July*, 1905.

A Ten-Thousand Horse-Power Steam Turbine. *Power, July*, 1905.

The Lentz High-Speed Steam Engine. *Power, July*, 1905.

Suggestions Concerning Valves. *Power, July*, 1905.

Steam Jacketing. *Electrician*, 28*th July*, 1905.

Feed Water Heaters. E. R. Briggs. *Engineer*, 28*th July*, 1905.

Modern Economical Steam Engines and Turbines. *Engineer*, 28*th July*, 1905.

Operating Features of Vertical Curtis Steam Turbines. Paper before Electrical Light Association. *Engineering Record*, 1*st July*, 1905.

Tests of a Vertical Cross-Compound Engine under Varying Loads. *Engineering Record*, 1*st July*, 1905.

Efficiency Tests of a 400-k.w. Steam Turbine. *Railway and Engineering Review*, 29*th July*, 1905.

Counterbalancing an Oscillating Engine. *Machinery, August*, 1905.

Modern Economical Steam Engines and Turbines, II. *Engineer*, 14*th July*, 1905.

Test of a Steam Turbine after two years' service. *Engineering Record*, 15*th July*, 1905.

Setting Direct and Indirect Link Motion. *Practical Engineer*, 28*th July*, 1905.

Power and Transmission.

Hydraulics.

The Selection of Waterworks Pumping Machinery, I. *Engineering Record*, 6*th July*, 1905.

Standard Hydraulic Pipe Flanges. *Machinery, August*, 1905.

72,000,000-Gallon Pumping Engine at Boston, Mass. *Engineering News*, 6*th July*, 1905.

Test of a Risdon-Sulzer 6-inch Centrifugal Pump. *American Machinist*, 29*th July*, 1905.

Multi-Stage Centrifugal Pumps for Elevator Service. *Machinery, July*, 1905.

Modern Types of Duplex and Fly-wheel Pumping Engines and Turbine Pumps. *Zeitschrift des Vereines Deutscher Ingr., 22nd July*, 1905.

Compressed Air.

Compressed Air Marking Machine, *American Machinist, 5th August*, 1905.

A High-Speed Electrically-Driven Compressor for Colliery Work. *Iron and Coal Trades Review, 14th July*, 1905,

Thermal Investigations of Compressors. *Zeitschrift des Vereines Deutscher Ingr., 8th* and *22nd July, 5th August*, 1905.

Shop Equipment and Practice.

Cutting Speeds for Shapers and Slotting Machines, Part I. *Modern Machinery, July*, 1905.

Semi-Automatic Hinge-Milling Machine. *American Machinist, 29th July*, 1905.

An English High-Speed Planer. *American Machinist, 5th August*, 1905.

A Modern Method of Venting Cores. *The Foundry, July*, 1905.

Standard Heads for Machine Screws. *Engineering News, 29th June*, 1905.

A General Theory of Spur Gearing. *Practical Engineering, 14th July*, 1905.

The Friction Clutch. *American Machinist, 15th July*, 1905.

Automatic Gear-Cutting Machine for Spur and Bevel Gears. *American Machinist, 15th July*, 1905.

A New Tool Steel. *American Manufacturer, 29th June*, 1905.

Standard Leading Screws for Lathes. *Engineering, 4th August*, 1905.

108-in. Lathe for turning Turbine Rotors. *Engineering, 28th July*, 1905.

Shop Tools and Devices. *Mechanical World, 14th July*, 1905.

Gang Milling of Repetition Castings. *Machinery, July*, 1905.

Machine Tool Design. Prof. Nicholson and Dempster Smith. *Engineer, 28th July*, 1905.

Miscellaneous.

Repairing a 400-Ton Hydraulic Press. *Machinery, August*, 1905,

Oil Grooves and the Fitting up of Bearings. *Mechanical World, 21st July*, 1905.

The Bursting Strength of Wooden Pulleys. *Machinery, August*, 1905.

New Methods of Testing Lubricants. *Engineer, Chic., 15th July*, 1905.

Some New Forms of Flanged Pipe Connections for High-Pressure Superheated Steam and Hydraulic Work. *Power, July*, 1905.

Combined Air Pump and Condenser. *Engineering, 21st July*, 1905.

Experiments on Bearing Friction. *Zeitschrift des Vereines Deutscher Ingr., 15th July*, 1905.

Oscillation of Pressure in Turbine Admission Pipes. *Zeitschrift Oester. Ingr. u. Arch. Vereines, 21st July*, 1905.

RAILWAY ENGINEERING.

Motive Power and Equipment.

Six-wheel (0—6—0) Switching Engine, Southern Railway. *Transport and Railroad Gazette, 14th July*, 1905.

Baldwin Four-Cylinder Balanced Compound Locomotives. *Railway Engineer, August*, 1905.

2—6—2 or "Prarie" Type Express Engine; Lake Shore and Michigan Southern R. R. *Railway Engineer, August*, 1905.

Steel Car for New York City Railway. *Railway Gazette, 11th August*, 1905.

A Study of the Walschært Valve Motion. *Railway Gazette, 11th August*, 1905.

7,000 Gal. Tender of the Louisville and Nashville. *Railway Gazette, 28th July*, 1905.

Four-Cylinder Balanced Compound—Oregon R. R. and Navigation Company. *Railway Master Mech., July*, 1905.

Heavy Switching Locomotive, New York Central Lines. *Railway and Engineering Review, 29th July*, 1905.

Cole Balanced Compound, Erie Railroad. *American Engineer and Railroad Journal, August*, 1905.

Compound Articulated Locomotives for the Central Northern Railway of the Argentine Republic. *Engineer, 4th August*, 1905.

An Improved Locomotive Blow-Off Valve. *Railway Age, 7th July*, 1905.

Central Vermont Compound Consolidation Locomotives. *Railway Age, 30th June*, 1905.

Pacific Type Four-cylinder Balanced Compound Locomotive. *Railway Age, 14th July*, 1905.

Locomotive Valves and Valve Gears. *Railway Gazette, 21st July*, 1905.

Union Pacific Gasoline Motor Car. *Railway Gazette, 21st July*, 1905.

Locomotive with Water Tube Boiler. *Le Genie Civil, 29th July*, 1905.

Motor Cars on British Railways. *Railway Age, 28th July*, 1905.

Permanent Way and Fixtures.

Steel Cross Ties. *Railway Gazette, 4th August*, 1905.

Treated Tie Data from the Santa Fé. *Railway Gazette, 4th August*, 1905.

Causes of Rail Failures in Service. *Railway and Engineering Review, 22nd July*, 1905.

The Deflection of Continuous Rail Bearers. *Engineering, 28th July*, 1905.

The Baltimore Terminal of the Western Maryland Railroad. *Engineering Record, 1st July*, 1905.

Some Causes of Failure of Rail in Service. *Engineering Record, 15th July*, 1905.

Turner's Automatic Point Controller. *Engineering, 28th July*, 1905.

Miscellaneous.

Planing Machine for Locomotive Frame Plates. *Engineering*, 21*st July*, 1905.

Power Signalling Installation on the Great Western. *Railway News*, 5*th August*, 1905.

Enlarging and Remodelling of Victoria Station, London, Brighton and South Coast Railway. *Railway Engineering*, *August*, 1905.

Recent Locomotive Developments on the London & N. W. Railway. *Iron and Coal Trades Review*, 26*th July*, 1905.

Princes Risborough and Grendon Underwood Railway. *Engineer*, 14*th July*, 1905.

Standard Length of Brake Beams. *Railway and Engineering Review*, 22*nd July*, 1905.

Traverser for the Western Railway of France. *Engineering*, 28*th July*, 1905.

The Hart Convertible Ballasting and Freight Car, and the work of Ballasting Track. *Engineering News*, 6*th July*, 1905.

Specifications for Cast Iron Car Wheels. *Railway and Engineering Review*, 22*th July*, 1905.

International Railway Congress I. *Engineer*, 21*st July*, 1905.

The "Leap Frog" Railway. *Scientific American*, 8*th July*, 1905.

AUTOMOBILISM AND ROAD TRACTION.

How a Differential Gear Works. *Autocar*, 5*th August*, 1905.

The Turner Carburettor. *Automotor Journal*, 5*th August*, 1905.

Future of Electro-Automobiles. *L'Electricien*, 22*nd July*, 1905.

ELECTRICAL ENGINEERING,

Electric Lighting.

A New Carbon Filament. *Western Electrician*, 15*th July*, 1905.

New System of Temporary Wiring. *Electrician*, 14*th July*, 1905.

On a Method of Potential Regulation based on the Different Resistance Behaviour of Carbon and Tantalum Lamps. *Electrical World and Engineer*, 1*st July*, 1905.

Uviol Mercury Lamps. *Elektrotechnische Zeitsch.*, 6*th July*, 1905.

Electrical Emergency Lighting, according to the System of Professor C. Hochenegg. *Elektrotechnische and Polytechnische Rundschau*, 15*th July*, 1905.

Generation and Transmission.

Details of the Wanamaker Power House, Philadelphia, I., II. *Engineering Record*, 22*nd* and 29*th July*, 1905.

Transmission of Power from Niagara to Toronto. *Electrical World and Engineer*, 1*st* and 8*th July*, 1905.

Recent Developments in Induction Motors. *Electrical World and Engineer*, 29*th July*, 1905.

A Long Distance Electric Power Transmission Line in Nevada. *Engineering News*, 6*th July*, 1905.

Transport of Electrical Energy at 40,000 volts between Gromo and Membro (Lombardy). *Le Genie Civil*, 8*th* and 15*th July*. 1905.

High Power Surges in Electric Distribution Systems of Great Magnitude. *Electrical Review*, *N.Y.*, 15*th July*, 1905.

Shunt Motors for Electric Cranes. *Electrical Review*, 14*th July*, 1905.

A New Single-Phase Motor. *Electrician*, 14*th July*, 1905.

Automatic Synchronizing of Generators and Rotaries. *Electricity*, *N.Y.*, 12*th July*, 1905.

Variable Speed Dynamo. *Electrical World and Engineer*, 15*th July*, 1905.

Regulation and Efficiency of Transmission Lines. *Electrical World and Engineer*, 1*st July*, 1905.

Single-Phase Induction Regulator. *Electrical World and Engineer*, 8*th July*, 1905.

Direct-Current Engine Type Generators. *Western Electrician*, 8*th July*, 1905.

Three-Wire Distribution for Factories. *Electrician*, 21*st July*, 1905.

Rotary Convertors and Motor Generators. *Western Electrician*. 15*th July*, 1905.

Automatic Synchronising of Generators and Rotaries. *Western Electrician*, 15*th July*, 1905.

Operation of Transformers at Varying Frequencies and Voltages. *Electrical Review*, *N.Y.*, 8*th July*, 1905.

Alternate Current Machinery-Induction Alternators. *Electrical Review*, *N.Y.*, 22*nd July*, 1905.

The Kinetic Variation of Pressure in Electric Generators. *Electrician*, 4*th August*, 1905.

Johnson-Lundell Regenerative System of Electric Traction. *Electrical Times*, 4*th August*. 1905.

Double Field Generators for Single-Phase and Rotary Currents. *Elektrotechnische Zeitsch.*, 6*th July*, 1905.

On a Simple Method of Ascertaining Drop of Tension in Transformers. *Elektrotechnische Zeitsch.*, 27*th July*, 1905.

Method of Determining Exciter Field Leakage of Alternators. *Elektrotechnische Polytechnische Rundschau*, 15*th July*, 1905.

Monolateral Magnetic Pull on Dynamos and Motors. *Zeitsch. Elektrotechnische*, 9*th July*, 1905.

Electric Traction.

Light Electric Railways. *Engineering News*, 29*th June*, 1905.

Sunderland District Tramways. *Tramway and Railway World*, 13*th July*, 1905.

Paisley and District Tramway System. *Tramway and Railway World*, 13*th July*, 1905.

The Development of the Single-Phase Railway System. *Engineering*, 28*th July*, 1905.

Automatic Signalling on Electric Railways. *Engineering News*, 13*th July*, 1905.

Heavy Traction Problems in Electrical Engineering. *Western Electrician*, 8*th July*, 1905.

Modern Electric Canal Haulage. *Modern Machinery*, *July*, 1905.

Automatic Regenerative Control. *Electrical Review*, 21*st July*, 1905.

Calcutta Electric Tramways. *Electrical Review*, 14*th July*, 1905.

Electric Railway Developments. *Scientific American*, 8th *July*, 1905.

Trolley Standards. *Electrical Times*, 27th *July*, 1905.

Rail-less Electric Traction. *Elektrotechnische Zeitscrift*, 6th *July*, 1905.

Modern Electrical Railway Systems, Conc. *Zeitschrift des Vereines, Deutscher Ingenieure*, 15th *July*, 1905.

Murnau-Oberammegau Single-Phase Railway. *Elek. Bahnen u Betriebe*, 14th and 24th *July*, 1905.

Electromagnetic Rail brake of the A. E. G. *Elek. Bahnen u Betriebe*, 24th *July*, 1905.

Electric Traction on Sebach-Wettingen Line by means of Single-Phase Currents of 1,500 volts. *L'Eclairage Electrique*, 29th *July*, 1905.

Rail-less Traction according to the Schumann System. *Dingler's Polytechnic Journal*, 8th *July*, 1905.

Miscellaneous.

A New Instrument for the Measurement of Alternating Currents. *Western Electrician*, 29th *July*, 1905.

The Variation of Electrical Resistance in the Contact of Carbon and Cast Iron. *Electric World and Engineer*, 15th *July*, 1905.

Electric Spark Recorder. *Electric World and Engineer*, 1st *July*, 1905.

Three-Phase Power Measurement without Wattmeters. *Electrician*, 21st *July*, 1905.

The Electric Driving of Reversing Rolling Mills. *Electrician*, 21st *July*, 1905.

Mercury Arc Rectifier. *Proceedings Engineers' Club*, Philadelphia, *July*, 1905.

The Mercury Vapour Convertor. *Electrical Review, N.Y.*, 22nd *July*, 1905.

Calculations for the Shaft, Gear, and Bearing of Crane Motors. *Machinery, July*, 1905.

Electricity in a Malleable Iron Foundry. *Electrical Review, N.Y.*, 8th *July*, 1905.

Time Limit Relays. *Electrician*, 28th *July*, 1905.

Insulation Testing—Apparatus and Methods. *Electrical Review, N.Y.*, 29th *July*, 1905.

Karljohansvaern Shipyard Electricity Works. *Tehnish Ugeblad*, 6th *July*, 1905.

Process of obtaining Calcium Carbide. *Elettricisita*, 1st *August*, 1905.

Checking Apparatus for Electrical Meters. *Elettricisita*, 14th *July*, 1905.

Danger Signalling Apparatus for Electrical Plants. *Elettricisita*, 4th *August*, 1905.

Contribution to the Construction of Fuses for Low Intensity Current Plants. *Elektrotechnishe Zeitschrift*, 20th *July*, 1905.

MARINE ENGINEERING AND NAVAL ARCHITECTURE.

Notes on the Trials of H.M.S. "Adventure." *Engineer*, 4th *August*, 1905.

Experiments on Resistance of Ships' Models. Paper before Institute Naval Architects. *Engineering*, 4th *August*, 1905.

Turbines and Reciprocating Engines in the Midland Railway Co.'s Boats. *Engineering*, 4th *August*, 1905.

Submarine Boats and their Salvage. Paper before Institute Naval Architects. *Engineering*, 28th *July*, 1905.

Lake Shipbuilding—A Masterpiece of System and Perfection of Detail. *Modern Machinery, July*, 1905.

Marine Gas Engines, III., the "Capitaine" Suction Producer. *Automotor Journal*, 15th *July*, 1905.

Gas Engine with Producer for Marine Use. *Engineering*, 4th *August*, 1905.

Experiments on the effect of depth of Water on Speed, having special reference to destroyers recently built. Abstract Paper before Institute Naval Architects. *Engineer*, 21st *July*, 1905.

The Machinery and Hull of Peary's new Arctic Ship. *Machinery, July*, 1905.

A Comparison of the Performances of Turbines and Reciprocating Engines in the Midland Railway Co.'s Steamers. Paper before Institute Naval Architects, July, 1905. *Marine Engineer, August*, 1905.

MUNICIPAL ENGINEERING.

Water Supply.

Water Purification at South Bethlehem, Philadelphia. *Engineering Record*, 15th *July*, 1905.

Recent Improvements in the Plant of the Danville Water Co. *Journal Western Society Engineers, June*, 1905.

Sewage.

Bacteriological Treatment of Sewage. *Proceedings Engineers' Club*, Philadelphia, *July*, 1905.

Some points in the Modern Treatment of Sewage. By Professor Bostock Hill. *Public Health Engineer*, 5th *August*, 1905.

Sewage Disposal at Elmhurst, N.Y. *Engineering Record*, 22nd *July*, 1905.

Streets and Pavements.

ENGINEERING ECONOMICS.

Estimating the Cost of Machine Work. *Machinery, July*, 1905.

MISCELLANEOUS.

The Field Gun of 1905. *Journal, Royal Artillery, July*, 1905.

Combined Telephony and Telegraphy. *Electrical Review*, 8th *July*, 1905.

Formulas and Computations for Horse Power Value of Streams. *Engineering Record*, 1st *July*, 1905.

Stereoscopic Vision applied to Surveying. *Proceedings, Engineers' Club, Philadelphia, July*, 1905.

Electric Devices for Deep Borehole Surveying. *Engineering News*, 27th *July*, 1905.

Fleuriais Collimater Gyroscope. *Der Mechaniker*, 20th *July*, 1905.

Universal geodetical instrument of the Mayer Wiesmann system. *Der Mechaniker*, 5th and 20th *July*, 1805.